

US EPA ARCHIVE DOCUMENT

**PROPOSED
TOTAL MAXIMUM DAILY LOAD (TMDL)**

**For
Nutrient
In
Lake Marian
(WBID 3184)**

Prepared by:

US EPA Region 4
61 Forsyth Street SW
Atlanta, Georgia 30303

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Acknowledgments

EPA would like to acknowledge that the contents of this report and the total maximum daily load (TMDL) contained herein were developed by the Florida Department of Environmental Protection (FDEP). Many of the text and figures may not read as though EPA is the primary author for this reason, but EPA is officially proposing the TMDL for nutrients for Lake Marian and is soliciting comment. EPA is proposing this TMDL in order to meet consent decree requirements pursuant to the Consent Decree entered in the case of Florida Wildlife Federation, et al. v. Carol Browner, et al., Case No. 98-356-CIV-Stafford. EPA will accept comments on this proposed TMDL for 30 days in accordance with the public notice issued on September 30, 2011. Should EPA be unable to approve a TMDL established by FDEP for the 303(d) listed impairment addressed by this report, EPA will establish this TMDL in lieu of FDEP, after full review of public comments.

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For additional information on the watershed management approach and impaired waters in The Upper Kissimmee River Planning Unit, contact:

Beth Alvi
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Planning and Coordination Section
2600 Blair Stone Road, Mail Station 3565
Tallahassee, FL 32399-2400
Elizabeth.alvi@dep.state.fl.us
Phone: (850) 245-8559;
Fax: (850) 245-8434

Access to all data used in the development of this report can be obtained by contacting:

Douglas Gilbert, Environmental Manager
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Evaluation and TMDL Section
2600 Blair Stone Road, Mail Station 3555
Tallahassee, FL 32399-2400
douglas.gilbert@dep.state.fl.us
Phone: (850) 245-8450;
Fax: (850) 245-8536

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Web sites

TMDL Program

<http://www.dep.state.fl.us/water/tmdl/index.htm>

Identification of Impaired Surface Waters Rule

<http://www.dep.state.fl.us/legal/Rules/shared/62-303/62-303.pdf>

Florida STORET Program

<http://www.dep.state.fl.us/water/storet/index.htm>

2010 Integrated Report

http://www.dep.state.fl.us/water/docs/2010_Integrated_Report.pdf

Criteria for Surface Water Quality Classifications

<http://www.dep.state.fl.us/legal/Rules/shared/62-302/62-302.pdf>

STORET Program

<http://www.dep.state.fl.us/water/storet/index.htm>

Basin Status Report for the Lake Holden Basin

<http://www.dep.state.fl.us/water/basin411/kissimmee/index.htm>

Assessment Report for the Lake Holden Basin

<http://www.dep.state.fl.us/water/basin411/kissimmee/index.htm>

U.S. ENVIRONMENTAL PROTECTION AGENCY, NATIONAL STORET PROGRAM

Region 4: TMDLs in Florida

<http://www.epa.gov/region4/water/tmdl/florida/>

National STORET Program

<http://www.epa.gov/storet/>

Chapter 1: INTRODUCTION

1.1 Purpose of Report

This report presents the TMDL for nutrients for Lake Marian, located in the Kissimmee River Basin. Lake Marian was verified as impaired during Cycle 1 (verified period from January 1, 1998 – June 30, 2005) by excessive nutrients using the methodology in the Identification of Impaired Surface Waters Rule (IWR, Rule 62-303, Florida Administrative Code), and was included on the Verified List of impaired waters for the Kissimmee River Basin that was adopted by Secretarial Order on May 12, 2006. Subsequently, during the Cycle 2 assessment (verified period from January 1, 2003 – June 30, 2010), the impairment was documented as continuing as the Trophic State Index (TSI) threshold of 60 was exceeded during both 2003 and 2007. The TMDL establishes the allowable loadings to the lake that would restore the waterbody so that it meets its applicable water quality narrative criteria for nutrients.

1.2 Identification of Waterbody

Lake Marian is located Osceola County, Florida. The estimated average surface area of the lake is 6,553 acres, with a normal pool volume of 46,819 acre/feet (ac/ft) and an average depth of 13 feet (ft). Lake Marian is an open hydrologic system. Lake Marian receives the drainage from the directly connected sub-basin drainage area of approximately 35,437 acres (**Figure 1.1**). The Lake Marian sub-basin watershed's land use designations are primarily agriculture (43%), wetland (21.2%), pastureland (23.2%), and rangeland/upland forest (10.9%). Lake Marian receives runoff from the local basin and discharges to Lake Jackson, which discharges to Lake Kissimmee. Lake Kissimmee discharges to the Kissimmee River.

For assessment purposes, the Department has divided the Kissimmee River Basin into water assessment polygons with a unique **waterbody identification (WBID)** number for each watershed or stream reach. Lake Marian has been given the WBID number of 3184. The Lake Marian WBID and its' sampling/monitoring stations are illustrated in **Figure 1.2**.

Figure 1.1 The Upper Kissimmee Planning Unit and Lake Marian Watershed

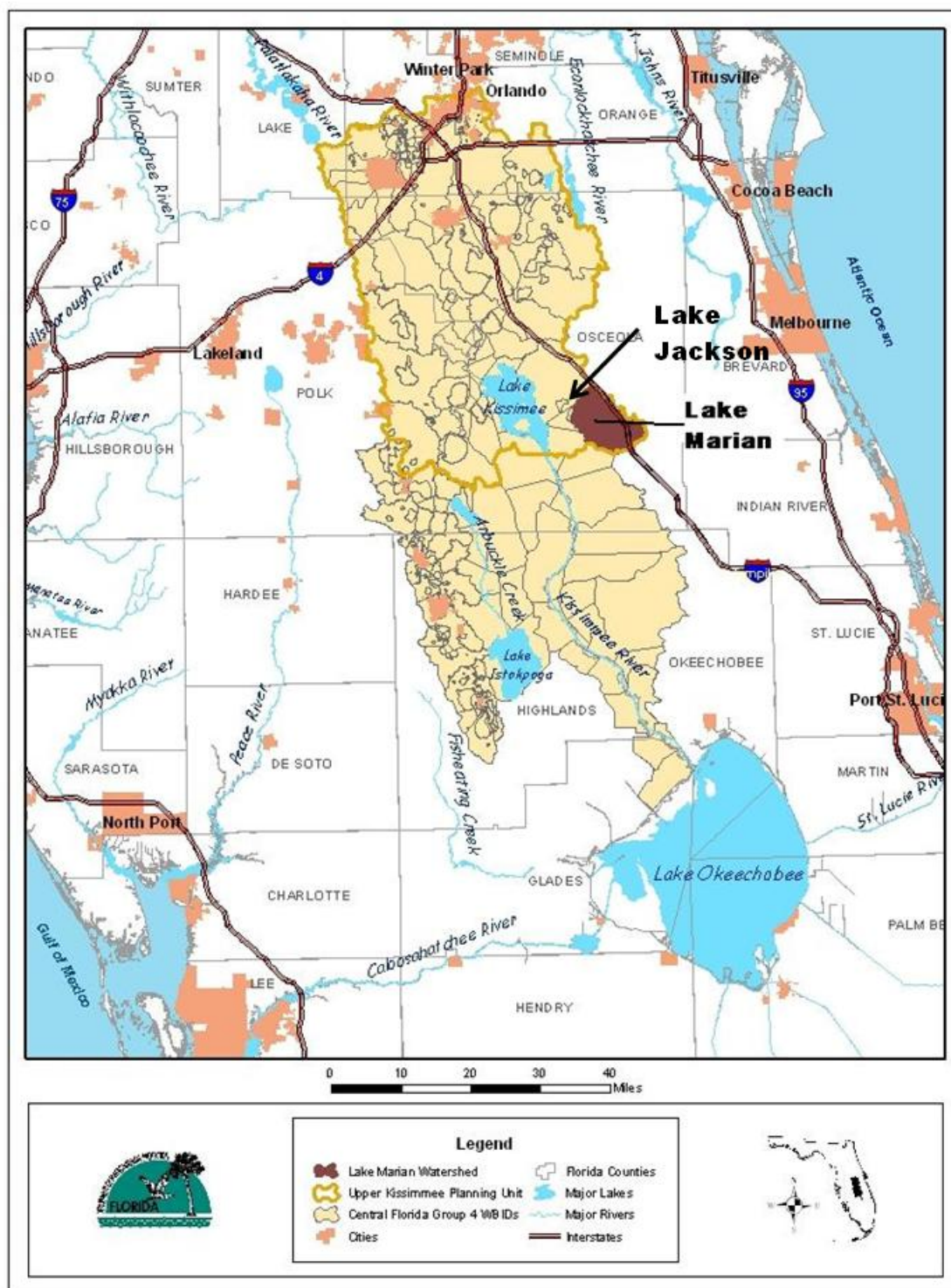
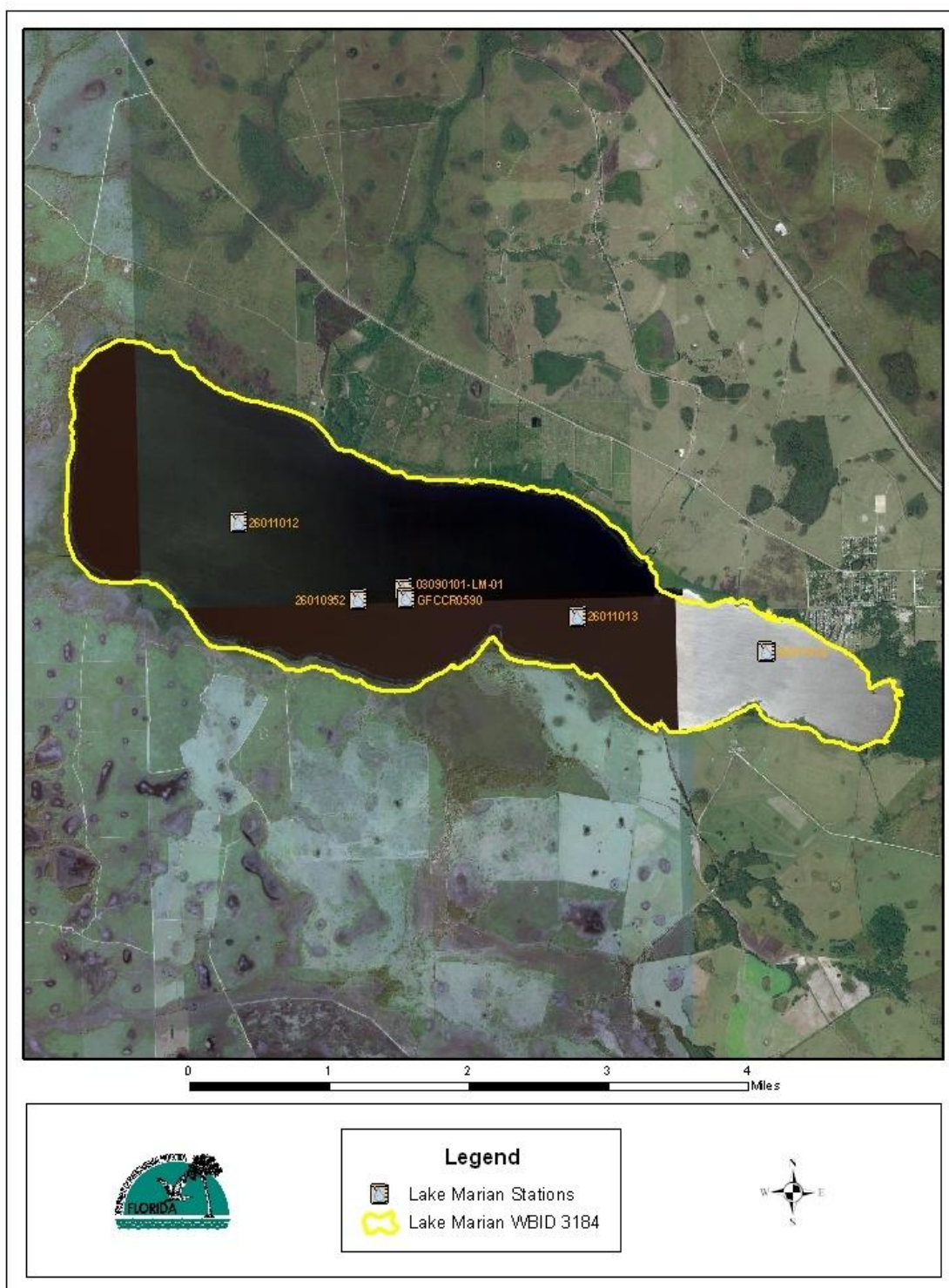


Figure 1.2 Lake Marian WBID 3184 and Monitoring Stations



1.3 Background Information

As depicted on **Figure 1.1**, the Lake Marian sub-basin has a total surface water drainage area of approximately 35,437 acres. The water in Lake Marian discharges to Lake Jackson, which flows into Lake Kissimmee. Thus, the water quality and quantity in Lake Marian directly influences water quality and quantity of these downstream receiving waterbodies, and ultimately, the Kissimmee River (**Figure 1.1**).

The TMDL Report for Lake Marian is part of the implementation of the Florida Department of Environmental Protection's (Department) watershed management approach for restoring and protecting water resources and addressing Total Maximum Daily Load (TMDL) Program requirements. The watershed approach, which is implemented using a cyclical management process that rotates through the state's fifty-two river basins over a five-year cycle, provides a framework for implementing the requirements of the 1972 federal Clean Water Act and the 1999 Florida Watershed Restoration Act (Chapter 99-223, Laws of Florida).

A TMDL represents the maximum amount of a given pollutant that a waterbody can assimilate and still meet the waterbody's designated uses. A waterbody that does not meet its designated uses is defined as impaired. TMDLs must be developed and implemented for each of the state's impaired waters, unless the impairment is documented to be a naturally occurring condition that cannot be abated by a TMDL or unless a management plan already in place is expected to correct the problem.

The development and implementation of a Basin Management Action Plan, or BMAP, to reduce the amount of pollutants that caused the impairment will follow this TMDL Report. These activities will depend heavily on the active participation of Osceola County, the water management district, local governments, local businesses, and other stakeholders. The Department will work with these organizations and individuals to undertake or continue reductions in the discharge of pollutants and achieve the established TMDLs for the impaired Lake.

Chapter 2: STATEMENT OF WATER QUALITY PROBLEM

2.1 Legislative and Rulemaking History

Section 303(d) of the federal Clean Water Act requires states to submit to the EPA a list of surface waters that do not meet applicable water quality standards (impaired waters) and establish a TMDL for each pollutant causing the impairment of the listed waters on a schedule. The Department has developed such lists, commonly referred to as 303(d) lists, since 1992. The list of impaired waters in each basin, referred to as the Verified List, is also required by the Florida Watershed Restoration Act (Subsection 403.067[4]) Florida Statutes [F.S.]), and the state's 303(d) list is amended annually to include basin updates.

Lake Marian was on Florida's 1998 303(d) list. However, the FWRA (Section 403.067, F.S.) stated that all previous Florida 303(d) lists were for planning purposes only and directed the Department to develop, and adopt by rule, a new science-based methodology to identify impaired waters. The Environmental Regulation Commission adopted the new methodology as Chapter 62-303, Florida Administrative Code (F.A.C.) (Identification of Impaired Surface Waters Rule, or IWR), in April 2001 and amended in 2006 and January 2007.

2.2 Information on Verified Impairment

The Department used the IWR to assess water quality impairments in Lake Marian. All data presented in this report are from IWR Run 41. All data included in **Appendix D** were processed by examining each result for appropriateness. Any results that were rejected are flagged with the remark code XX. Data reduction followed the procedures in Rule 62-303, F.A.C. Data were further reduced by calculating daily averages. These are the data from which graphs and summary statistics were prepared. The annual averages were calculated from these data by averaging for each calendar quarter and then averaging the four quarters to determine the annual average. The lake was verified as impaired for nutrients based on an elevated annual average Trophic State Index (TSI) value over the Cycle 1 verification period (the Verified Period for the Group 4 basins was from January 1, 1998 – June 30, 2005). The impaired condition was documented as still present during the Cycle 2 verified period from January 1, 2003 – June 30, 2010. The IWR methodology uses the water quality variables total nitrogen (TN), total phosphorus (TP), and chlorophyll *a* (a measure of algal mass, corrected and uncorrected) in calculating annual TSI values and in interpreting Florida's narrative nutrient threshold. For Lake Marian, data were available for the three water quality variables for all four seasons in 1998, 1999, 2000, 2002, 2003, and 2007 of the Cycle 1 and Cycle 2 verified periods. The resulting annual average TSI values for these years are 71.9, 76.2, 76.4, 72.2, 66.5, and 72.9 respectively. Per the IWR methodology, exceeding a TSI of 60 in lakes with color over 40 PCU in any one year of the verified period is sufficient in determining nutrient impairment. Only limited color data were available for Lake Marian. Annual average color values for the verified period (for years with color values in all 4 quarters) for the lake were 110 PCU (1998), 80 PCU (1999), and 110 PCU in 2007. The daily average (**Figure 2.1**) and annual average (**Figure 2.2**) color values for the period of record (1966 – 2009) have increased slightly over time, as has the alkalinity (**Figure 2.3**) and pH (**Figure 2.4**), while the Secchi disk depth has remained almost constant over the same period of time (**Figure 2-5**).

Figure 2.1 Daily Average Color (PCU) 1966 - 2009

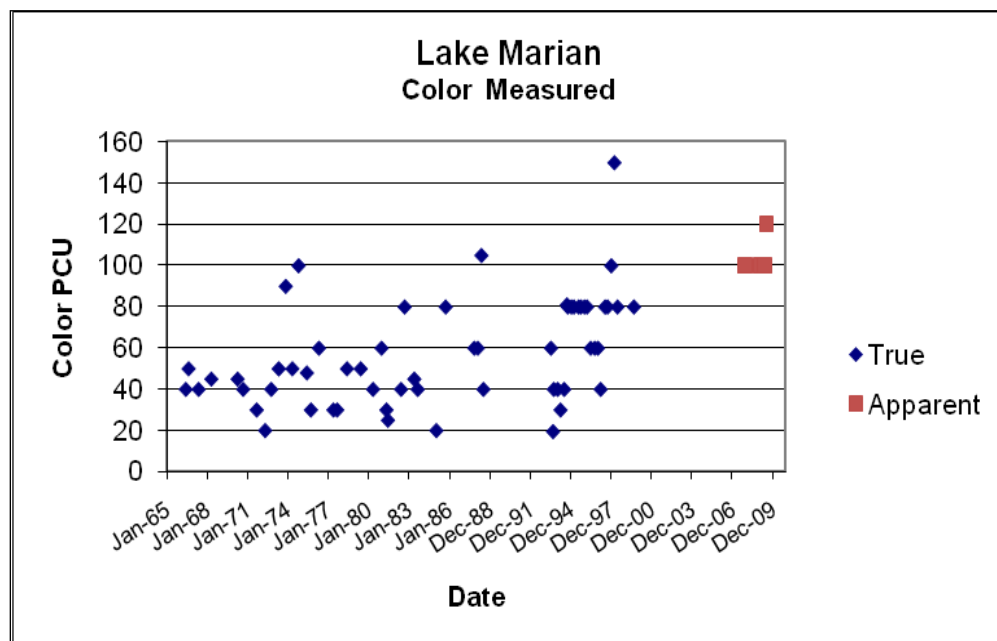


Figure 2.2 Annual Average Color (PCU) 1966 - 2009

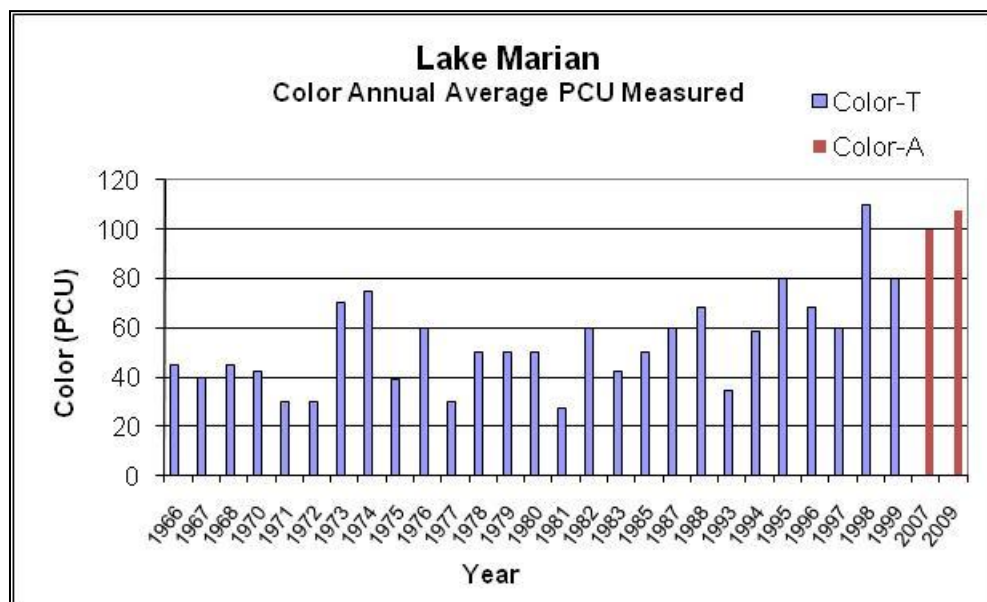


Figure 2.3 Daily Average Alkalinity (mg/L) 1966 - 2009

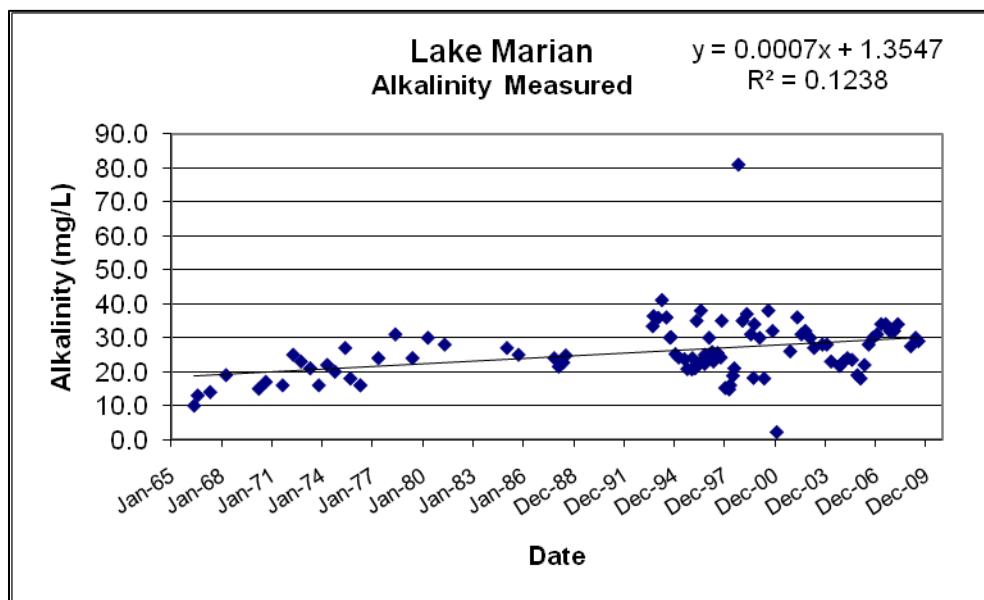


Figure 2.4 Daily Average pH (su) 1966 - 2009

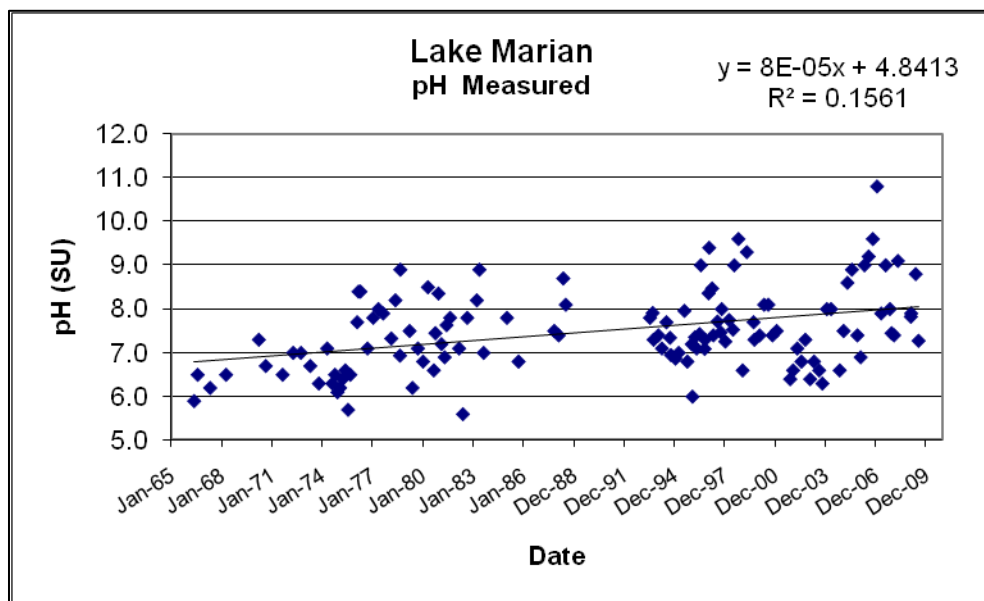
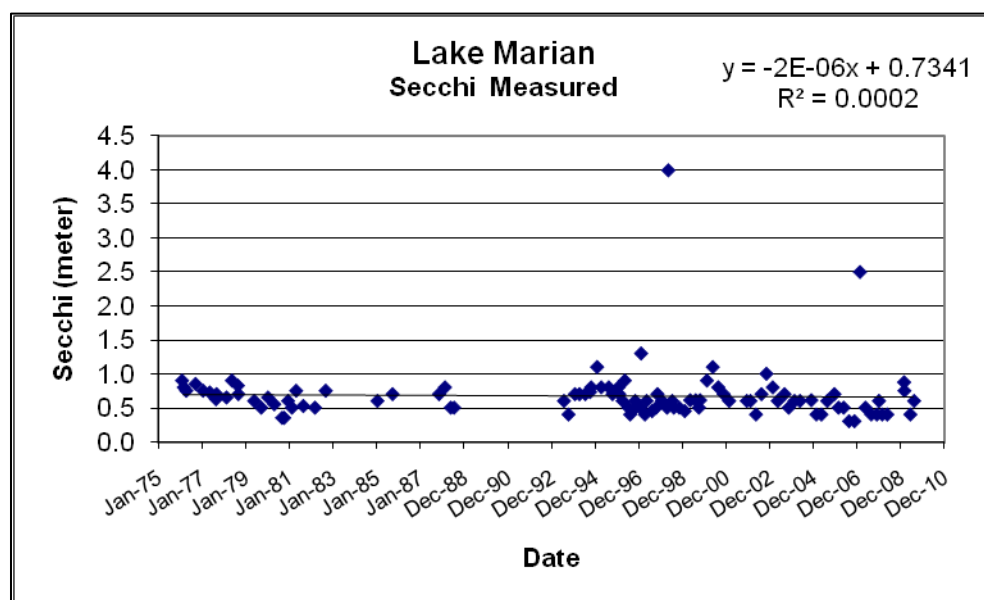


Figure 2.5 Daily Average Secchi (meters) 1976 - 2009



The TSI is calculated based on concentrations of TP, TN, and chlorophyll *a* as follows:

$$CHLA_{TSI} = 16.8 + 14.4 * \ln(\text{Chl } a)$$

$$TN_{TSI} = 56 + 19.8 * \ln(N)$$

$$TN2_{TSI} = 10 * [5.96 + 2.15 * \ln(N + 0.0001)]$$

$$TP_{TSI} = 18.6 * \ln(P * 1000) - 18.4$$

$$TP2_{TSI} = 10 * [2.36 * \ln(P * 1000) - 2.38]$$

Chlorophyll *a* in µg/L

Nitrogen in mg/L

Phosphorus in mg/L

If $N/P > 30$, *then* $NUTR_{TSI} = TP2_{TSI}$

If $N/P < 10$, *then* $NUTR_{TSI} = TN2_{TSI}$

if $10 < N/P < 30$, *then* $NUTR_{TSI} = (TP_{TSI} + TN_{TSI})/2$

$$TSI = (CHLA_{TSI} + NUTR_{TSI})/2$$

Note: TSI has no units

The Hydrologic Simulation Program Fortran (HSPF) model was run for years 1996 – 2006. However, 1996 was used to allow the model to establish antecedent conditions and model comparisons to measured data were only conducted for years 1997 – 2006. For modeling purposes, the analysis of the eutrophication-related data presented in this report for Lake Marian used “all” of the available data from 1997 – 2006 for which records of TP, TN, and chlorophyll *a* were sufficient to calculate seasonal and annual average conditions. However, the comparisons in the Camp Dresser and McKee (CDM), 2008 report do not contain any LakeWatch data. Additionally, to calculate the TSI for a given year under the IWR, there must be at least one sample of TN, TP, and chlorophyll *a* taken within the same quarter (each season) of the year. The absence of data for at least one of the four seasons caused the elimination of the years 2001, 2004, 2005, and 2006 from the analysis of TSI for Lake Marian.

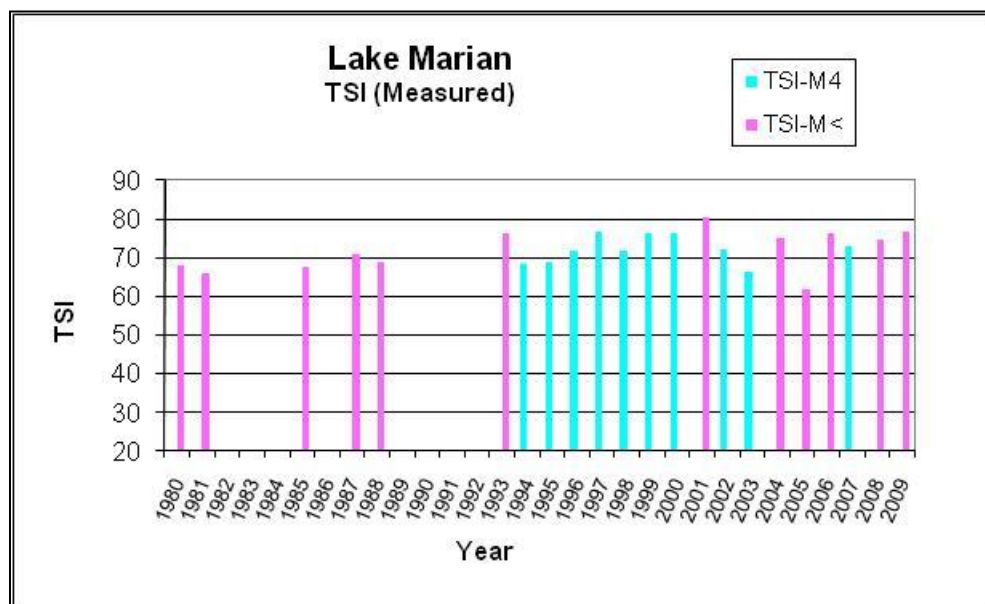
Key to Figure Legends Calculation of Annual Averages

M< = results for measured data, does not include data from all four quarters

M4 = results for measured data, at least one set of data from all four quarters

Figure 2.6 displays annual average TSI values for all data from 1980 to 2009 (includes Lakewatch data). Annual averages labeled “M<” do not contain data from all 4 quarters and were not used in the determination of impairment. The Cycle 1 verified period (January 1998 – June 2006) annual average TSI values exceeded the IWR threshold level of 60 in years 1998, 1999, 2000, 2002, and 2003 with an overall mean TSI result of 73.3. The TSI exceeded the threshold in Cycle 2 for years 2003 (66.5) and 2007 (72.9)

Figure 2.6 TSI Results for Lake Marian Calculated from Annual Average Concentrations of TP, TN, and Chlorophyll a from 1980 to 2009



Daily, annual, and monthly average TN results for Lake Marian from 1971 to 2009 are displayed in **Figures 2.7, 2.8, and 2.9**, respectively. Daily, annual, and monthly average TP results from 1970 to 2009 are displayed in **Figures 2.10, 2.11, and 2.12**, respectively. Daily, annual, and monthly average corrected chlorophyll a (CChla) results from 1980 to 2009 are displayed in **Figures 2.13, 2.14, and 2.15**, respectively. The daily and annual average values from all stations for TN indicate very little if any change over the period of record. TN monthly results were typically higher during November through February and lowest in late summer and early fall. The daily and annual average values from all stations for TP indicate a slight increase over the period of record. TP monthly results were typically rising during early fall and lowest in spring and mid-summer. The daily and annual average values from all stations for CChla indicate a slight increase over the period of record. CChla monthly results were typically highest in spring and summer and lowest in late fall and winter.

Figure 2.7 Total Nitrogen Daily Average Results for Lake Marian from 1971 to 2009

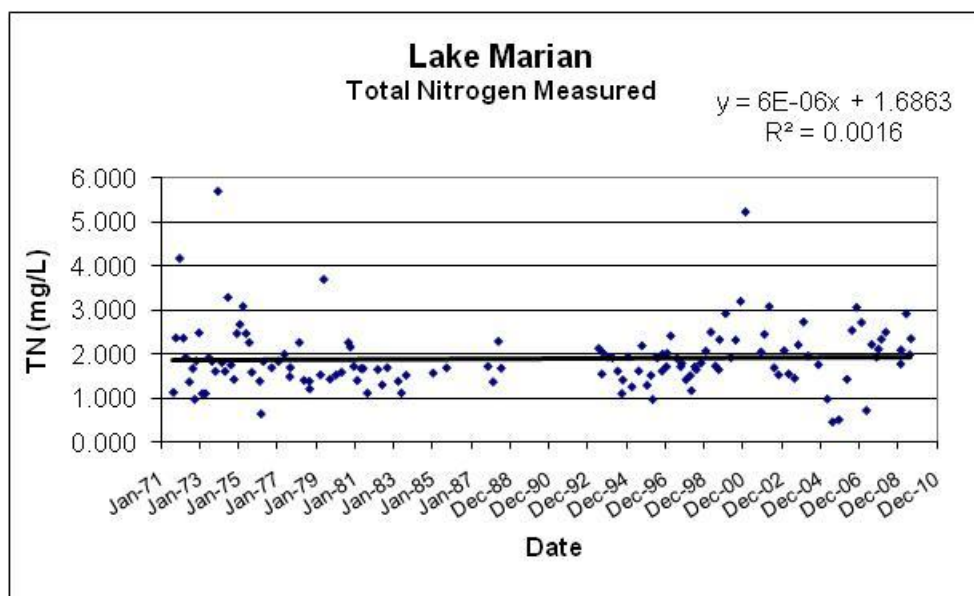


Figure 2.8 Total Nitrogen Annual Average Results for Lake Marian from 1971 to 2009

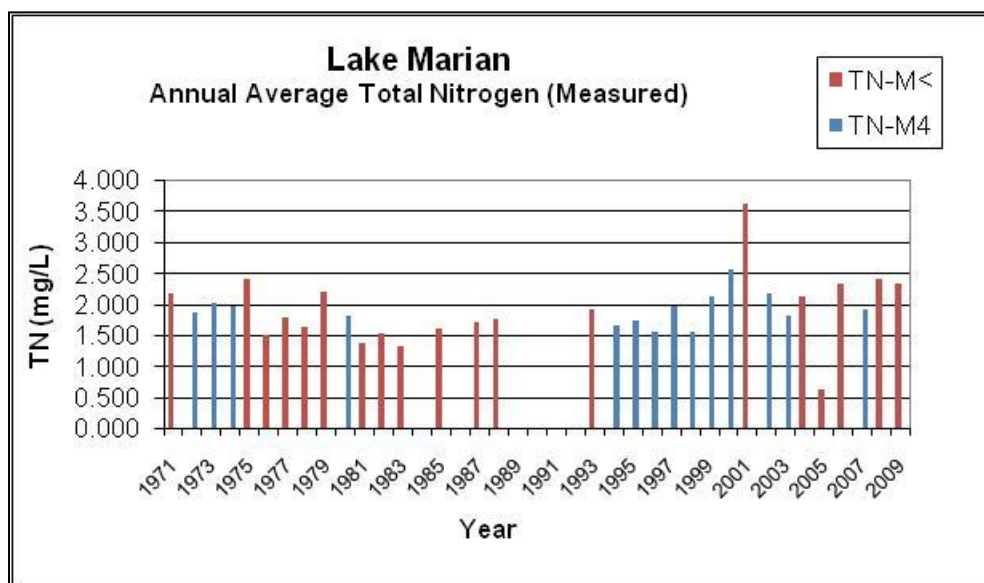


Figure 2.9 Total Nitrogen Monthly Average Results for Lake Marian from 1971 to 2009

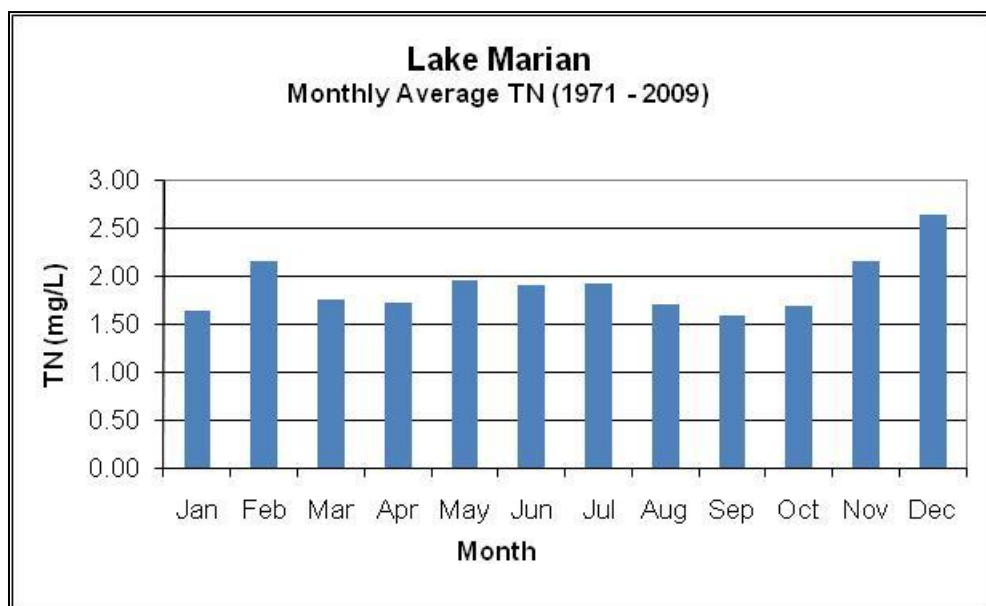


Figure 2.10 Total Phosphorus Daily Average Results for Lake Marian from 1970 to 2009

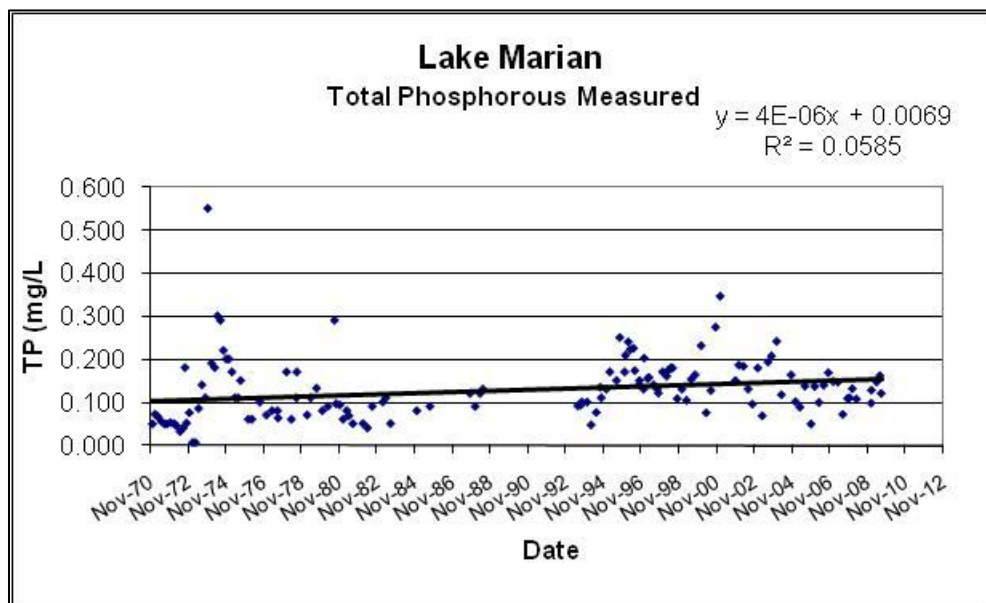


Figure 2.11 Total Phosphorus Annual Average Results for Lake Marian from 1970 to 2009

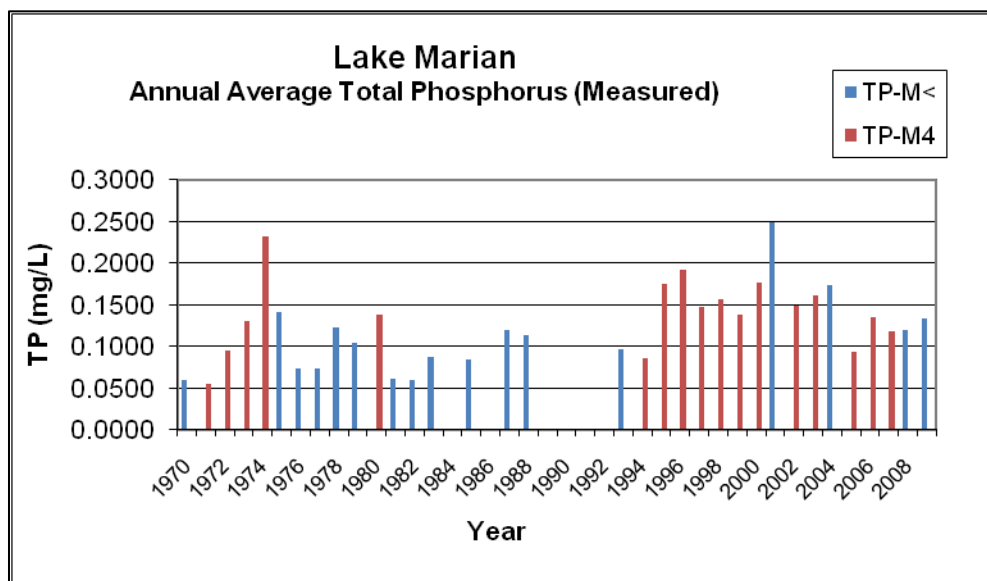


Figure 2.12 Total Phosphorus Monthly Average Results for Lake Marian from 1970 to 2009

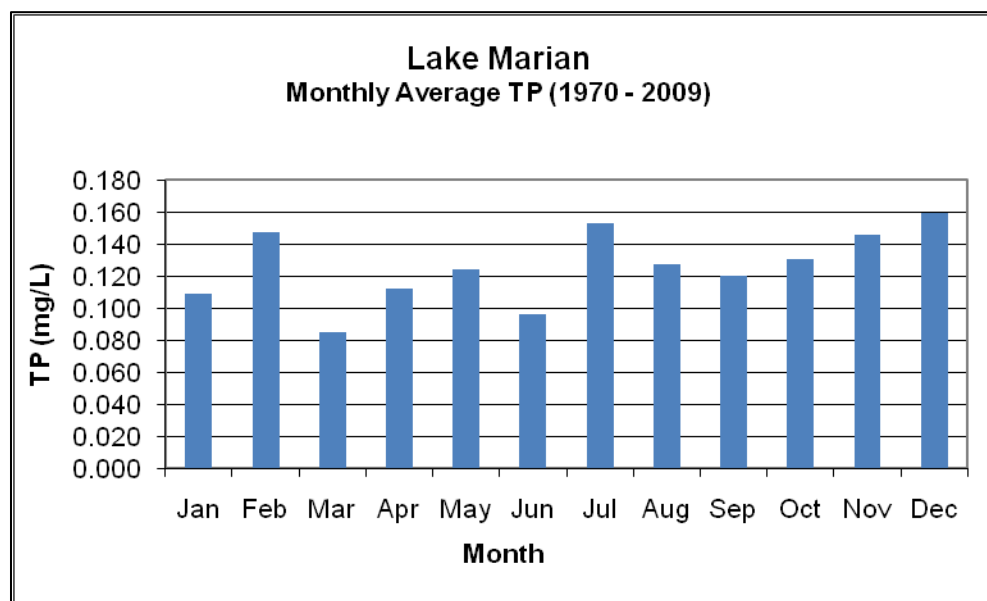


Figure 2.13 Chlorophyll a Daily Average Results for Lake Marian from 1980 to 2009

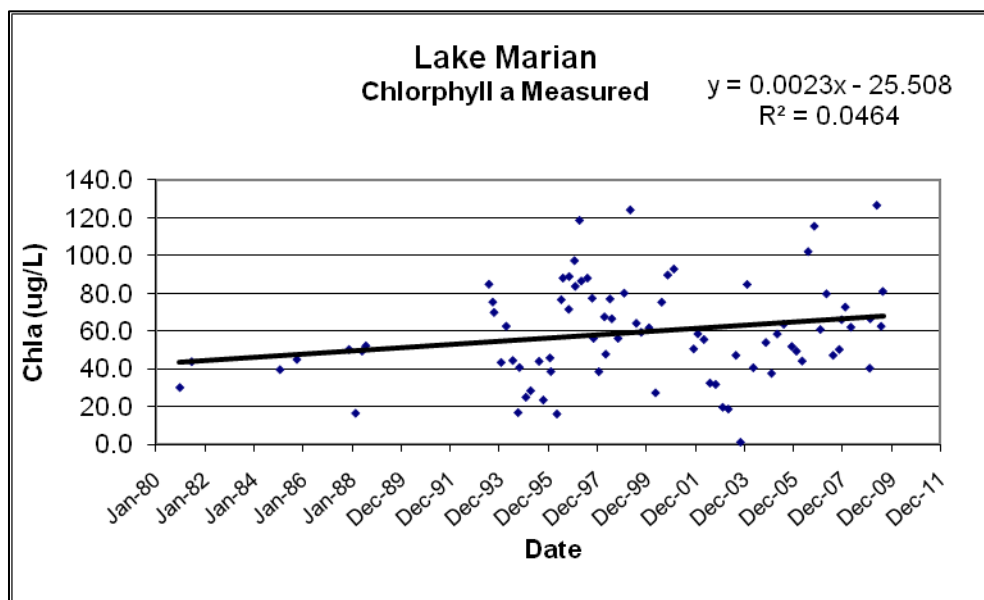


Figure 2.14 Chlorophyll a Annual Average Results for Lake Marian from 1980 to 2009

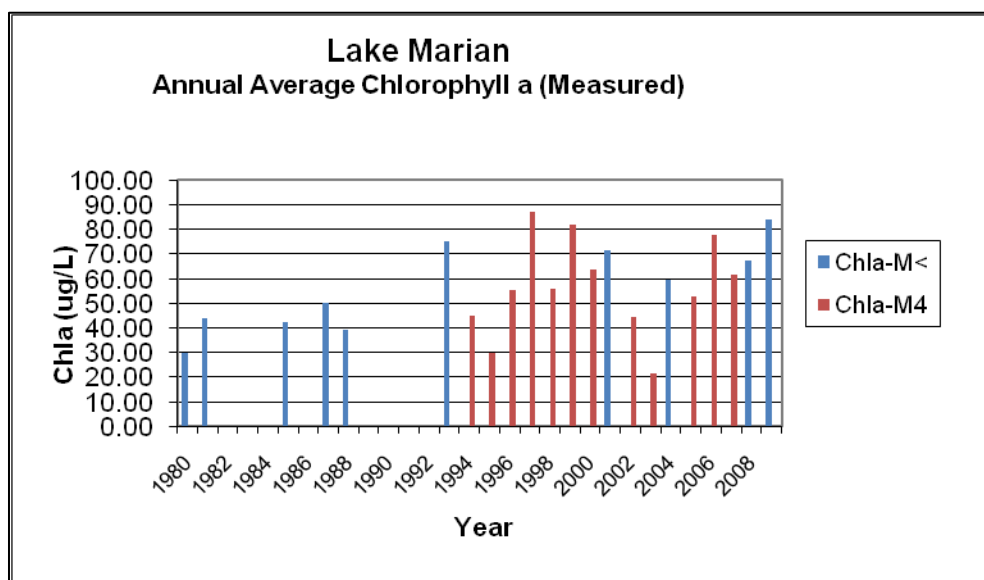


Figure 2.15 Chlorophyll *a* Monthly Average Results for Lake Marian from 1980 to 2009

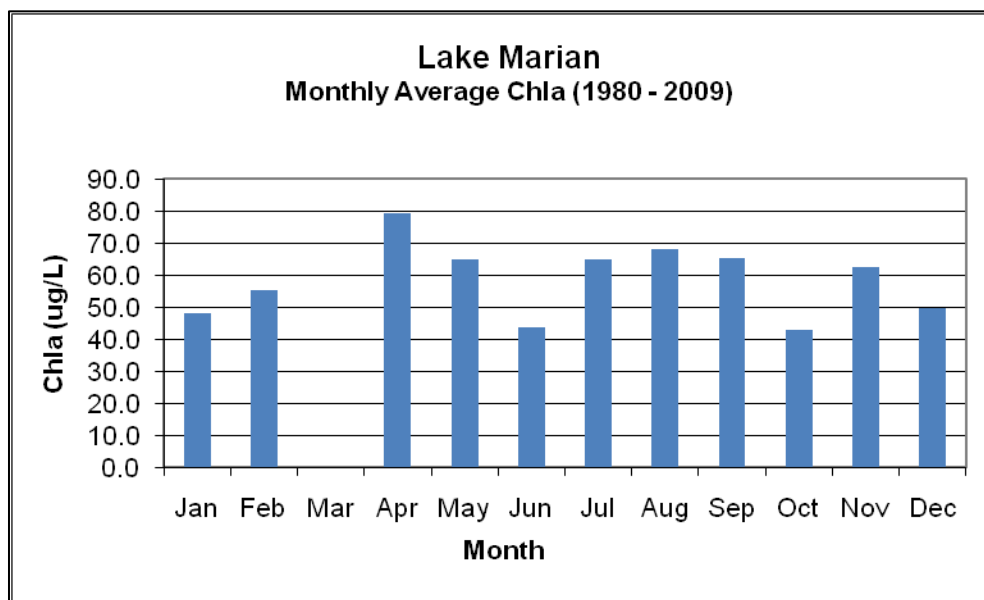


Table 2.1 provides summary statistics for the lake for TN, TP, and chlorophyll *a* from 1993 to 2006. Individual water quality measurements (raw data) for TN, TP, and chlorophyll *a* used in the assessment are provided in **Appendix D**.

Table 2.1 *Water Quality Summary Statistics for TN, TP, Chlorophyll *a*, Color, Alkalinity, pH, and Secchi from 1966 to 2009 for Lake Marian*

Water Quality Parameter	Period of Record	# of Samples	Minimum	Maximum	Mean	Median	Standard Deviation
Total Nitrogen (mg/L)	1971-2009	134	0.450	5.690	1.896	1.746	0.737
Total Phosphorus (mg/L)	1970-2009	143	0.006	0.550	0.128	0.117	0.072
Chlorophyll <i>a</i> (ug/L)	1980-2009	81	1.0	126.7	59.0	56.1	25.9
Color (PCU)	1966-2009	58	19.5	150.0	57.3	50.0	25.5
Alkalinity (mg/L)	1966-2009	96	2.20	81.00	26.07	25.00	9.04
ph (su)	1966-2009	127	5.60	10.80	7.49	7.40	0.92
Secchi (m)	1976-2009	103	0.30	4.00	0.68	0.60	0.42

Chapter 3. DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND TARGETS

3.1 Classification of the Waterbody and Criteria Applicable to the TMDL

Florida's surface water is protected for five designated use classifications, as follows:

Class I	Potable water supplies
Class II	Shellfish propagation or harvesting
Class III	Recreation, propagation, and maintenance of a healthy, well-balanced population of fish and wildlife
Class IV	Agricultural water supplies
Class V	Navigation, utility, and industrial use (there are no state waters currently in this class)

Lake Marian is classified as Class III freshwater waterbody, with a designated use of recreation, propagation and maintenance of a healthy, well-balanced population of fish and wildlife. The Class III water quality criterion applicable to the observed impairment for Lake Marian is the state of Florida's narrative nutrient criterion [Rule 62-302.530(48) (b), FAC].

3.2 Interpretation of the Narrative Nutrient Criterion for Lakes

To place a waterbody segment on the Verified List for nutrients, the Department must identify the limiting nutrient or nutrients causing impairment as required by the IWR. The following method is used to identify the limiting nutrient(s) in streams and lakes:

The individual ratios over the entire verified periods for Cycle 1 (i.e., January 1998 to June 2005) and Cycle 2 (i.e., January 1, 2003 to June 30, 2010) were evaluated to determine the limiting nutrient(s). If all the sampling event ratios are less than 10, nitrogen is identified as the limiting nutrient, and if all the ratios are greater than 30, phosphorus is identified as the limiting nutrient. Both nitrogen and phosphorus are identified as limiting nutrients if the ratios are between 10 and 30. Although for 1998 and 2005, the lake was nitrogen-limited; the mean TN/TP ratio was 14.2 for the Cycle 1 and Cycle 2 periods, indicating co-limitation of TP and TN for the lake.

Florida's nutrient criterion is narrative only, i.e., nutrient concentrations of a body of water shall not be altered so as to cause an imbalance in natural populations of aquatic flora or fauna. Accordingly, a nutrient-related target was needed to represent levels at which an imbalance in flora or fauna is expected to occur. While the IWR provides a threshold for nutrient impairment for lakes based on annual average TSI levels, these thresholds are not standards and are not required to be used as the nutrient-related water quality target for TMDLs. In recognition that the IWR thresholds were developed using statewide average conditions, the IWR (Subsection 62-303.450, F.A.C.) specifically allows the use of alternative, site-specific thresholds that more accurately reflect conditions beyond which an imbalance in flora or fauna occurs in the waterbody.

The TSI originally developed by R. E. Carlson (1977) was calculated based on Secchi depth, chlorophyll concentration, and total phosphorus concentration and was used to describe a lake's trophic state. Carlson's TSI was developed based on the assumption that the lakes were all phosphorus limited. In Florida, because the local geology produced a phosphorus rich soil, nitrogen can be the sole or co-limiting factor for phytoplankton population in some lakes. In

addition, because of the existence of dark-water lakes in the state, using Secchi depth as an index to represent lake trophic state can produce misleading results.

Therefore, the TSI was revised to be based on total nitrogen, total phosphorus, and chlorophyll *a* concentrations. This revised calculation for TSI now contains options for determining a TN - TSI, TP -TSI, and Chlorophyll *a* -TSI. As a result, there are three different ways of calculating a final in-lake TSI. If the TN to TP ratio is equal to or greater than 30, the lake is considered phosphorus-limited and the final TSI is the average of the TP -TSI and the Chlorophyll *a* -TSI. If the TN to TP ratio is 10 or less, the lake is considered nitrogen-limited and the final TSI is the average of the TN -TSI and the Chlorophyll *a* -TSI. If the TN to TP ratio is between 10 and 30, the lake is considered co-limited and the final TSI is the result of averaging the Chlorophyll *a* -TSI with the average of the TN and TP TSIs.

The Florida-specific TSI was determined based on the analysis of data from 313 Florida lakes. The index was adjusted so that a chlorophyll *a* concentration of 20 µg/L was equal to a Chlorophyll *a* -TSI value of 60. The final TSI for any lake may be higher or lower than 60, depending on the TN -TSI and the TP -TSI values. A TSI of 60 was then set as the threshold for nutrient impairment for most lakes (for those with a color higher than 40 platinum cobalt units) because, generally, the phytoplankton may switch to communities dominated by blue-green algae at chlorophyll *a* levels above 20 µg/L. These blue-green algae are often an unfavorable food source to zooplankton and many other aquatic animals. Some blue-green algae may even produce toxins, which could be harmful to fish and other animals. In addition, excessive growth of phytoplankton and the subsequent death of these algae may consume large quantities of dissolved oxygen and result in anaerobic conditions in lakes, which makes conditions in the impacted lake unfavorable for fish and other wildlife. All of these processes may negatively impact the health and balance of native fauna and flora.

Because of the amazing diversity and productivity of Florida lakes, almost all lakes have a natural background TSI that is different from 60. In recognition of this natural variation, the IWR allows for the use of a lower TSI (40) in very clear lakes, a higher TSI if paleolimnological data indicate the lake was naturally above 60, and the development of site-specific thresholds that better represent the levels at which nutrient impairment occurs.

For the Lake Marian TMDL, the Department applied the HSPF model to simulate water quality discharges and eutrophication processes to determine the appropriate nutrient target. The HSPF model was used to estimate existing conditions in the Lake Marian watershed and the background TSI by setting land uses to natural or forested land, and then compare the resulting TSI to the IWR thresholds. When the background TSI can be reliably determined and represents an appropriate target for TMDL development, then an increase of 5 TSI units above background will be used as the water quality target for the TMDL; this would be indicative of protecting the designated use. The HSPF estimated average background TSI for Lake Marian is 60.4. The model also indicated that in its background condition, the lake was sometimes TP-limited, but usually strongly co-limited, with an average TN/TP ratio of 24.7. This results in a restoration target TSI of 65 (rounded down from 65.4) and a lake mostly exhibiting nutrient co-limitation.

3.3 Narrative Nutrient Criteria Definitions

Chlorophyll *a*

Chlorophyll is a green pigment found in plants and is an essential component in the process of converting light energy into chemical energy. Chlorophyll is capable of channeling the energy of sunlight into chemical energy through the process of photosynthesis. In photosynthesis, the energy absorbed by chlorophyll transforms carbon dioxide and water into carbohydrates and oxygen. The chemical energy stored by photosynthesis in carbohydrates drives biochemical reactions in nearly all living organisms. Thus, chlorophyll is at the center of the photosynthetic oxidation-reduction reaction between carbon dioxide and water.

There are several types of chlorophyll; however, the predominant form is chlorophyll a. The measurement of chlorophyll a in a water sample is a useful indicator of phytoplankton biomass, especially when used in conjunction with analysis concerning algal growth potential and species abundance. Typically, the greater the abundance of chlorophyll a, in a waterbody the greater the abundance of algae. Algae are the primary producers in the aquatic food web, and thus are very important in characterizing the productivity of lakes and streams. As noted earlier, chlorophyll a measurements are also used to estimate the trophic conditions of lakes and lentic waters.

Nitrogen Total as N (TN)

Total nitrogen is the combined measurement of nitrate (NO_3), nitrite (NO_2), ammonia, and organic nitrogen found in water. Nitrogen compounds function as important nutrients to many aquatic organisms and are essential to the chemical processes that exist between land, air, and water. The most readily bio-available forms of nitrogen are ammonia and nitrate. These compounds, in conjunction with other nutrients, serve as an important base for primary productivity.

The major sources of excessive amounts of nitrogen in surface water are the effluent from municipal treatment plants and runoff from urban and agricultural sites. When nutrient concentrations consistently exceed natural levels, the resulting nutrient imbalance can cause undesirable changes in a waterbody's biological community and drive an aquatic system into an accelerated rate of eutrophication. Usually, the eutrophication process is observed as a change in the structure of the algal community and includes severe algal blooms that may cover large areas for extended periods. Large algal blooms are generally followed by depletion in dissolved oxygen concentrations as a result of algal decomposition.

Phosphorus Total as P (TP)

Phosphorus is one of the primary nutrients that regulates algal and macrophyte growth in natural waters, particularly in fresh water. Phosphate, the form in which almost all phosphorus is found in the water column, can enter the aquatic environment in a number of ways. Natural processes transport phosphate to water through atmospheric deposition, ground water percolation, and terrestrial runoff. Municipal treatment plants, industries, agriculture, and domestic activities also contribute to phosphate loading through direct discharge and natural transport mechanisms. The very high levels of phosphorus in some of Florida's streams and estuaries are sometimes linked to phosphate mining and fertilizer processing activities.

High phosphorus concentrations are frequently responsible for accelerating the process of eutrophication, or accelerated aging, of a waterbody. Once phosphorus and other important nutrients enter the ecosystem, they are extremely difficult to remove. They become tied up in biomass or deposited in sediments. Nutrients, particularly phosphates, deposited in sediments generally are redistributed to the water column. This type of cycling compounds the difficulty of halting the eutrophication process.

Chapter 4: ASSESSMENT OF SOURCES

4.1 Overview of Modeling Process

The Lake Marian watershed is a part of a larger network of lakes and streams that drain to the Kissimmee River, and ultimately, Lake Okeechobee. As there are several other lakes/streams in the Kissimmee River Basin for which TMDLs are being developed, the Department contracted with CDM to gather all available information and to setup, calibrate, and validate HSPF model projects for these waters. See Appendix B for modeling details.

HSPF (EPA, 2001 and Brickell *et al.*, 2001) is a comprehensive package that can be used to develop a combined watershed and receiving water model. The external load assessment conducted using HSPF was intended to determine the loading characteristics of the various sources of pollutants to Lake Marian. Assessing the external load entailed assessing land use patterns, soils, topography, hydrography, point sources, service area coverages, climate, and rainfall to determine the volume, concentration, timing, location, and underlying nature of the point, nonpoint, and atmospheric sources of nutrients to the lake.

The model has the capability of modeling various species of nitrogen and phosphorus, chlorophyll *a*, coliform bacteria, and metals in receiving waters (bacteria and metals can be simulated as a “general” pollutant with potential instream processes including first-order decay and adsorption/desorption with suspended and bed solids). HSPF has been developed and maintained by Aqua Terra and the EPA and is available as part of the EPA supported software package BASINS (Better Assessment Science Integrating point and Nonpoint Sources). The PERLND (pervious land) module performs detailed analyses of surface and subsurface flow for pervious land areas based on the Stanford Watershed Model. Water quality calculations for sediment in pervious land runoff can include sediment detachment during rainfall events and reattachment during dry periods, with potential for washoff during runoff events. For other water quality constituents, runoff water quality can be determined using buildup-washoff algorithms, “potency factors” (e.g., factors relating constituent washoff to sediment washoff), or a combination of both. The IMPLND (impervious land) module performs analysis of surface processes only and uses buildup-washoff algorithms to determine runoff quality. The RCHRES module is used to simulate flow routing and water quality in the receiving waters, which are assumed to be one-dimensional. Receiving water constituents can interact with suspended and bed sediments through soil-water partitioning. HSPF can incorporate “special actions” that utilize user-specified algorithms to account for occurrences such as opening/closing of water control structures to maintain seasonal water stages or other processes beyond the normal scope of the model code.

More information on HSPF / BASINS can be found at www.epa.gov/waterscience/basins/.

4.2 Potential Sources of Nutrients in the Lake Marian Watershed

An important part of the TMDL analysis is the identification of pollutant source categories, source subcategories, or individual sources of the pollutant of concern in the watershed and the amount of pollutant loading contributed by each of these sources. Sources are broadly classified as either “point sources” or “nonpoint sources.” Historically, the term point sources has meant discharges to surface waters that typically have a continuous flow via a discernable, confined, and discrete conveyance, such as a pipe. Domestic and industrial wastewater treatment facilities (WWTFs) are examples of traditional point sources. In contrast, the term “nonpoint sources” was used to describe intermittent, rainfall driven, diffuse sources of pollution

associated with everyday human activities, including runoff from urban land uses, agriculture, silviculture, and mining; discharges from failing septic systems; and atmospheric deposition.

However, the 1987 amendments to the Clean Water Act redefined certain nonpoint sources of pollution as point sources subject to regulation under the EPA's National Pollutant Discharge Elimination Program (NPDES). These nonpoint sources included certain urban stormwater discharges, including those from local government master drainage systems, construction sites over five acres, and a wide variety of industries (see **Appendix A** for background information on the federal and state stormwater programs). To be consistent with Clean Water Act definitions, the term "point source" will be used to describe traditional point sources (such as domestic and industrial wastewater discharges) and stormwater systems requiring an NPDES stormwater permit when allocating pollutant load reductions required by a TMDL. However, the methodologies used to estimate nonpoint source loads do not distinguish between NPDES stormwater discharges and non-NPDES stormwater discharges, and as such, this source assessment section does not make any distinction between the two types of stormwater.

4.2.1 Point Sources

There are no permitted wastewater treatment facilities or industrial wastewater facilities that discharge directly to Lake Marian. The facilities listed in **Table 4.1** are within the Lake Marian watershed, but were not included in the model, as they are not surface water dischargers.

Table 4.1 NPDES Facilities

NPDES Permit ID	Facility Name	Receiving Water	Permitted Capacity (mgd)	Downstream Impaired WBID	Comments
FLA010989	Lake Marian Paradise WWTF	None	0.02	Not Applicable	No surface water discharge

Municipal Separate Storm Sewer System Permittees

Municipal separate storm sewer systems (MS4s) may discharge nutrients to waterbodies in response to storm events. To address stormwater discharges, the EPA developed the NPDES stormwater permitting program in two phases. Phase I, promulgated in 1990, addresses large and medium MS4s located in incorporated places and counties with populations of 100,000 or more. Phase II permitting began in 2003. Regulated Phase II MS4s, which are defined in Section 62-624.800, F.A.C., typically cover urbanized areas serving jurisdictions with a population of at least 10,000 or discharge into Class I or Class II waters, or Outstanding Florida Waters.

The stormwater collection systems in the Lake Marian watershed, which are owned and operated by Osceola County, are covered by NPDES Phase II MS4 permit number FLR04E012. The collection system for the Florida Department of Transportation District 5 is covered by NPDES permit number FLR04E024. The collections systems for the Florida Turnpike are covered by NPDES permit number FLR04E049.

4.2.2 Nonpoint Sources and Land Uses

Unlike traditional point source effluent loads, nonpoint source loads enter at so many locations and exhibit such large temporal variation that a direct monitoring approach is often infeasible. For the Lake Marian TMDL, all nonpoint sources were evaluated by use of a watershed and lake modeling approach. Land use coverages in the watershed and sub-basin were aggregated using the Florida Land Use, Cover and Forms Classification System (FLUCCS, 1999) into nine different land use categories. These categories are cropland/improved pasture/tree crops (agriculture), unimproved pasture/woodland pasture (pasture), rangeland/upland forests, commercial/industrial, high density residential (HDR), low density residential (LDR), medium density residential (MDR), water, and wetlands. The spatial distribution and acreage of different land use categories for HSPF were identified using the 2000 land use coverage (scale 1:24,000) provided by the South Florida Water Management District (SFWMD).

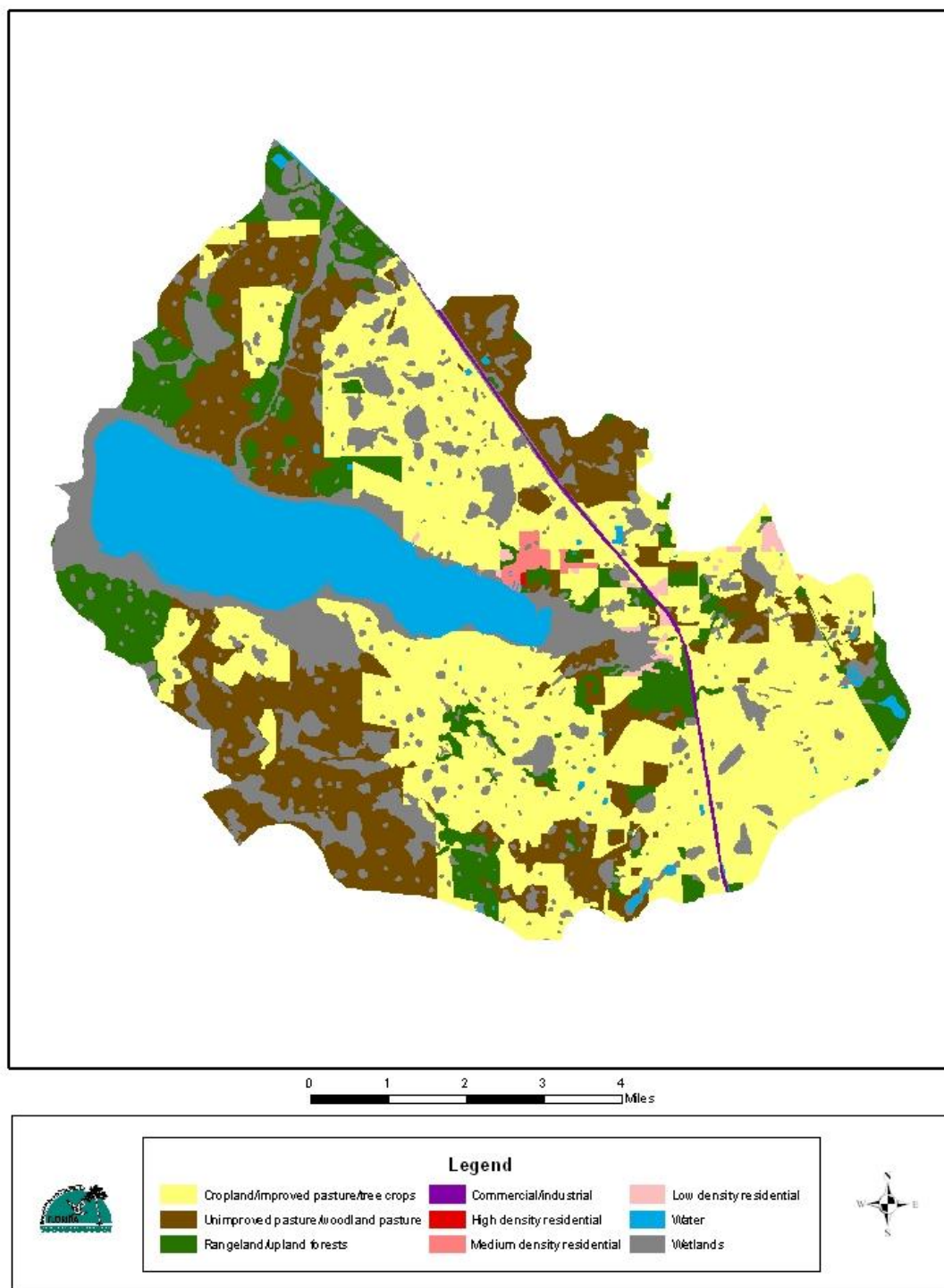
Table 4.2 shows the existing area of the various land use categories in the Lake Marian watershed (surface area of water not included). **Figure 4.1** shows the drainage area of Lake Marian and the spatial distribution of the land uses shown in **Table 4.2**.

The predominant land uses for the Lake Marian watershed include agriculture (43%), wetland (21.2%), forest/rangeland (10.9%), pastureland (23.2%), commercial/industrial (0.6%), residential housing (1.1%).

Table 4.2 Lake Marian Watershed Existing Land Use Description

Lake Marion Watershed Existing Land Use Coverage	Watershed	Watershed
	Acres	Percent
Agriculture	15,254.00	43.05
Wetland	7,502.10	21.17
Forest/Rangeland	3,857.00	10.88
Pastureland	8,211.40	23.17
Commercial/Industrial	225.90	0.64
High Density Residential	3.40	0.01
Medium Density Residential	138.80	0.39
Low Density Residential	244.30	0.69
Sum	35,436.90	100.00

Figure 4.1 Lake Marian Watershed Existing Land Use Coverage



Osceola County Population

According to the U.S Census Bureau (U. S. Census Bureau Web site, 2008), the county occupies an area of approximately 1,321.9 square miles (sq mi). The total population in 2000 for Osceola County, which includes (but is not exclusive to) the Lake Marian watershed, was 172,493. The population density in Osceola County, in the year 2000, was at or less than 130.5 people per sq mi. The Bureau estimates the 2006 Osceola County population at 244,045 (185 people/sq mi). For all of Osceola County (2006), the Bureau reported a housing density of 83 houses per sq mi. Osceola County is well below the average housing density for Florida counties of 158 housing units per sq mi.

Septic Tanks

Onsite sewage treatment and disposal systems (OSTDSs), including septic tanks, are commonly used where providing central sewer is not cost-effective or practical. When properly sited, designed, constructed, maintained, and operated, OSTDSs are a safe means of disposing of domestic waste. The effluent from a well-functioning OSTDS is comparable to secondarily treated wastewater from a sewage treatment plant. When not functioning properly, however, OSTDSs can be a source of nutrients (nitrogen and phosphorus), pathogens, and other pollutants to both ground water and surface water. Section 2.5.2.1 Septic Tanks, of the CDM, 2008 report describes in detail how septic tanks were included in the HSPF model. In general, the HSPF model does not directly account for the impacts of failing septic tanks. CDM came to the conclusion that failing septic tanks were not believed to have significant impacts on Lake Marian and therefore not explicitly included in the model, because (a) there is a limited amount of urban land in the study area, (b) failure rates are typically low (10% failing or less), and (c) the amount of urban land believed to be served by septic tanks is also low in the study area.

Osceola County Septic Tanks

As of 2006, Osceola County had a cumulative registry of 24,148 septic systems. Data for septic tanks are based on 1971 – 2006 census results, with year-by-year additions based on new septic tank construction. The data do not reflect septic tanks that have been removed going back to 1970. From fiscal years 1994–2006, an average of 157.4 permits/year for repairs was issued in Osceola County (Florida Department of Health, 2008). Based on the number of permitted septic tanks estimated for 2006 (24,148) and housing units (109,892) located in the county, approximately 78 percent of the housing units are connected to a central sewer line (i.e., wastewater treatment facility), with the remaining 22 percent utilizing septic tank systems.

Table 4.3 Septic Tank Coverage for Urban Land Uses

Receiving Water	HSPF Model Reach	Septic Tank Coverage (%)			
		Commercial	HDR	LDR	MDR
Lake Marian	450	0	99	21	22

¹ Septic tank coverage estimated based on available septic tank and sewer service area information.

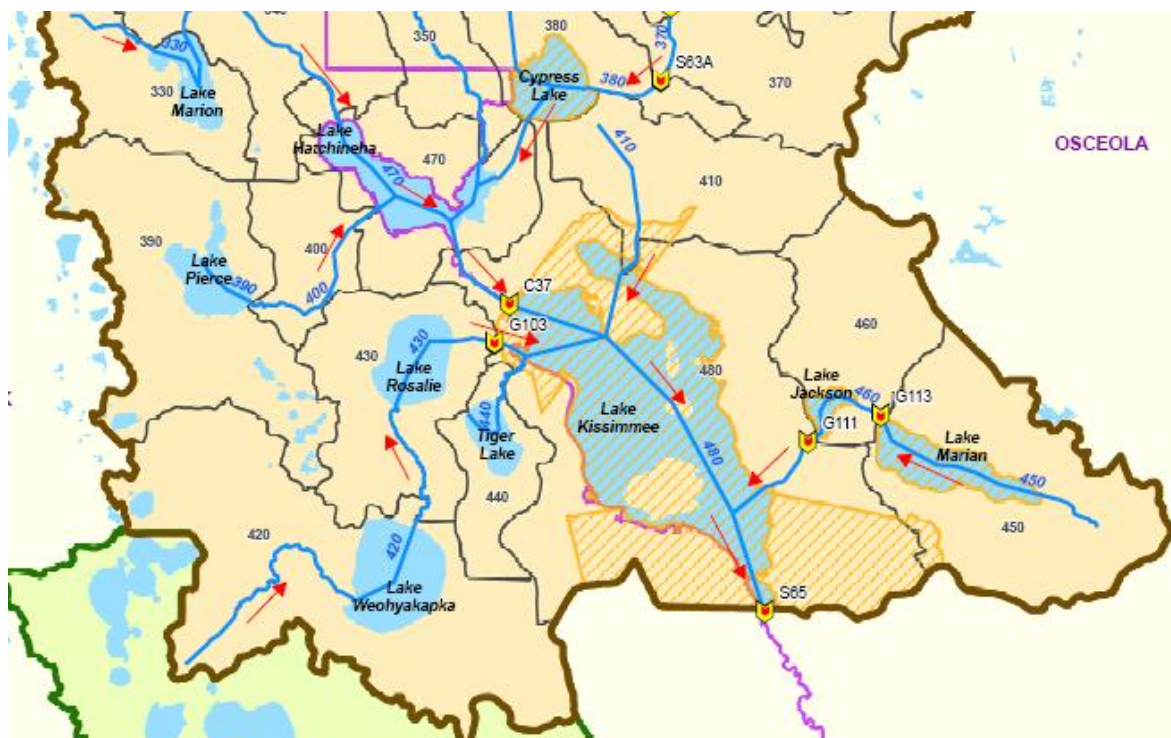
4.3 Estimating Point and Nonpoint Source Loadings

Model Approach

The HSPF model was utilized to estimate the nutrient loads within and discharged from the Lake Marian Basin. The HSPF model allows the Department to interactively simulate and assess the environmental effects of various land use changes and associated land use practices. The model was run for 1996 through 2006. The year 1996 was used to establish antecedent conditions (model spin-up). Model calibration was performed for January 1997 through December 2000 and model validation was performed for January 2001 through December 2006. All measured data and model result comparisons (including those in Chapter 3 for developing TMDL targets) are for years 1997 through 2006. Additionally both calibration and validation comparisons are “point to point” in that only model results from the day corresponding to the same day as the measured data are used for assessing calibration and validation.

The water quality parameters (impact parameters) simulated within the model for Lake Marian include: water quantity (surface runoff, interflow and baseflow), and water quality (total nitrogen, organic nitrogen, ammonia nitrogen, NOX nitrogen, total phosphorus, organic phosphorus, ortho-phosphorus, phytoplankton as biologically active chlorophyll *a* (corrected), temperature, total suspended solids, dissolved oxygen, and ultimate carbonaceous biological oxygen demand). Datasets of land use, soils and rainfall are used to calculate the combined impact of the watershed characteristics for a given modeled area on a waterbody represented in the model as a reach. Lake Marian receives runoff from the local basin and discharges to Lake Jackson through structure G113, which discharges to Lake Kissimmee through structure G111. Lake Kissimmee discharges to the Kissimmee River through structure S65. **Figure 4.2** depicts the model basins, reaches, and control structures.

Figure 4.2 Lake Marian Modeled Watershed Flow Routing and Reach Numbers



GIS and model data set used to derive the inputs for HSPF included land use, soils, topography and depressions, hydrography, USGS gage and flow data, septic tanks, water use pumpage, point sources, rainfall, ground water, atmospheric deposition, solar radiation, control structures, and stream reaches.

IMPLND Module for Impervious Tributary Area

The IMPLND module of HSPF accounts for surface runoff from impervious land areas (e.g., parking lots and highways). For the purposes of this model, each land use was assigned a typical percentage of directly connected impervious area (DCIA), as shown in **Table 4.4** based on published values (CDM, 2002). Four of the nine land uses contain some impervious areas.

Table 4.4 Percentage of Impervious Area

Land Use Category	% DCIA
1. Commercial / Industrial	80
2. Cropland / Improved pasture / Tree crops	0
3. High density residential	50
4. Low density residential	10
5. Medium density residential	25
6. Rangeland / Upland Forests	0
7. Unimproved pasture / Woodland pasture	0
8. Wetlands	0
9. Water	0

Note: Most of the water and wetland land uses in the system are modeled as a "reach" in HSPF.

PERLND Module for Pervious Tributary Area

The PERLND module of HSPF accounts for surface runoff, interflow, and ground water flow (baseflow) from pervious land areas. For the purposes of modeling, the total amount of pervious tributary area was estimated as the total tributary area minus the impervious area.

HSPF uses the Stanford Watershed Model methodology as the basis for hydrologic calculations. This methodology calculates soil moisture and flow of water between a number of different storages, including surface storage, interflow storage, upper soil storage zone, a lower soil storage zone, an active ground water zone, and deep storage. Rain that is not converted to surface runoff or interflow infiltrates into the soil storage zones. The infiltrated water is lost by evapotranspiration, discharged as baseflow, or lost to deep percolation (e.g., deep aquifer recharge). In the HSPF model, water and wetlands land uses were generally modeled as pervious land (PERLND) elements. Since these land use types are expected to generate more flow as surface runoff than other pervious lands, the PERLND elements representing water and wetlands were assigned lower values for infiltration rate (INFILT), upper zone nominal storage (UZSN), and lower zone nominal storage (LZSN).

Hydrology for large waterbodies (e.g., lakes) and rivers and streams that connect numerous lakes throughout the Project Area were modeled in RCHRES rather than PERLND (see Section 4.3.1.3 of the CDM, 2008 report). For each sub-basin containing a main stem reach, a number

of acres were removed from the water land use in PERLND, which were modeled explicitly in RCHRES. The acres removed from these sub-basins correspond to the areas of the lakes and the streams. In the reaches representing these waterbodies, HSPF accounted for direct rainfall on the water surface and direct evaporation from the water surface.

Several of the key parameters adjusted in the analysis include the following:

- LZSN (lower zone nominal storage) - LZSN is the key parameter in establishing an annual water balance. Increasing the value of LZSN increases the amount of infiltrated water that is lost by evapotranspiration and, therefore, decreases the annual stream flow volume.
- LZETP (lower zone evapotranspiration parameter) – LZETP affects the amount of potential evapotranspiration that can be satisfied by lower zone storage and is another key factor in the annual water balance.
- INFILT (infiltration) - INFILT can also affect the annual water balance. Increasing the value of INFILT decreases surface runoff and interflow, increases the flow of water to the lower soil storage and ground water, and results in greater evapotranspiration.
- UZSN (upper zone nominal storage) - Reducing the value of UZSN increases the percentage of flow that is associated with surface runoff, as opposed to ground water flow. This would be appropriate for areas where receiving water inflows are highly responsive to rainfall events. Increasing UZSN can also affect the annual water balance by resulting in greater overall evapotranspiration.

RCHRES Module for Stream/Lake Routing

The RCHRES module of HSPF conveys flows input from the PERLND and IMPLND modules, accounts for direct water surface inflow (rainfall) and direct water surface outflow (evaporation), and routes flows based on a rating curve supplied by the modeler. Within each sub-basin of each planning unit model, a RCHRES element was developed, which defines the depth-area-volume relationship for the modeled waterbody.

The depth-area-volume relationships for Lake Marian were developed based on the lake's bathymetry data. Section 4.2.10 of the CDM, 2008 report provides more detailed information of how the lake bathymetry data were used to develop the depth-area-volume relationships.

For the lakes with hydraulic control structures, the design discharge rates were used in the depth-area-volume-discharge relationships once the lake stages were one foot or more than the target levels. When the lake stages were between 0 and 1 foot above the targets, the flows were assumed to vary linearly between zero (0 foot above target) and the design flows (1 foot above target).

As discussed in Section 4.2.11 of the CDM, 2008 report, the depth-area-volume relationships for the reaches in the Upper Kissimmee Planning Unit were developed based on the cross-section data extracted from the other models.

An initial Manning's roughness coefficient value of 0.035, typical for natural rivers and streams, was used in flow calculations. In some instances, the roughness coefficient value was adjusted during the model calibrations to reflect local conditions, such as smaller values for well-maintained canals and bigger values for meandering, highly vegetated, and not well-defined

streams. The slopes of water surface (S) were approximated with the reach bottom slopes, which were estimated based on the Digital Elevation Model data.

Implementation of Hydraulic Control Structure Regulation Schedules

In order to simulate the hydraulic control structure regulation schedules in the HSPF models, the stages were approximated with step functions as described in detail in Section 4 of the CDM, 2008 report. Variable step functions were used to approximate different regulation schedules. In each approximation, a step function was defined such that stage variations generally equaled one foot. In several instances, however, stage variations were less than one foot or less than 1.5 feet due to the stage variations in the original regulation schedules. For each hydraulic control structure, a sequential dataset was created to mimic the regulation schedules. Sequential datasets in this HSPF modeling application define the discharge column to evaluate from the FTABLE.

An FTABLE is a table in the HSPF model input file that summarizes the geometric and hydraulic properties of a reach. Normally, an FTABLE has at least 3 columns: depth, surface area, and volume. For the FTABLE associated with a reach with a control structure, columns 4 through 8 can be used to define control structure operation flow rates for different operation zones. For example, the approximated operation schedule for a given lake may have four operation zones (1 through 4). For each year from January 1st to April 5th (zone 1), the sequential dataset instructs the HSPF model to use the discharge rate in Column 4 in the FTABLE. Similarly, Columns 5, 6, 7 in the FTABLE are used as the operation schedule progresses into Zones 2, 3, and 4, respectively.

Based on discussions with operations staff, actual operations often did not follow the regulation schedules due to various reasons; therefore, an accurate match between the measured stages and flows and those simulated were not expected. Instead, annual water and nutrient budgets for each impaired WBID were the focus.

Lake Marian Existing Land Use Loadings

The HSPF simulation of pervious lands (PERLNDs) and impervious lands (IMPLNDs) calculates hourly values of runoff from pervious and impervious land areas, and interflow and baseflow from pervious lands, plus loads of water quality constituents associated with these flows. For PERLNDs, TSS (sediment) was simulated in HSPF by accounting for sediment detachment caused by rainfall, and subsequent washoff of the detached sediment when surface runoff occurs. Loads of other constituents in PERLND runoff were calculated in the GQUAL (general quality constituent) model of HSPF, using a “potency factor” approach (*i.e.*, defining how many pounds of constituent are washed off per ton of sediment washed off).

One exception occurs for dissolved oxygen (DO), which HSPF evaluates at the saturation DO concentration in surface runoff. For PERLNDs, concentrations of constituents in baseflow were assigned based on typical values observed in several tributaries in the study area such as Boggy Creek and Reedy Creek, and interflow concentration were set at values between the estimated runoff and baseflow concentrations. For IMPLNDs, TSS (sediment) is simulated by a “buildup-washoff” approach (buildup during dry periods, washoff with runoff during storm events) and again the “potency factor” approach was used in the IQUAL module for other constituents except DO, which again was analyzed at saturation.

The “general” water quality constituents that were modeled in HSPF include the following:

- Ammonia Nitrogen;
- Nitrate Nitrogen;
- CBOD (ultimate);
- Ortho-Phosphate; and
- Refractory Organic Nitrogen.

One feature of HSPF is that the CBOD concentration has associated concentrations of organic-N and organic-P. Consequently, the TN concentration is equal to the sum of ammonia-N, nitrate-N, refractory organic-N, and a fraction of the CBOD concentration. Similarly, the TP concentration is equal to the sum of ortho-P and a fraction of the CBOD concentration.

The total loadings of nitrogen and phosphorus for Lake Marian were estimated using the HSPF model. Modeling frameworks were designed to simulate the period 1996 through 2006. The model year 1996 was used to establish antecedent conditions, the model results are summarized for years 1997 – 2006. This period is inclusive of the Cycle 1 verified period for Group 4 waterbodies and most of the Cycle 2 verified period.

Chapter 5: DETERMINATION OF ASSIMILATIVE CAPACITY

5.1 Determination of Loading Capacity

Nutrient enrichment and the resulting problems related to eutrophication tend to be widespread and are frequently manifested far (in both time and space) from their source. Addressing eutrophication involves relating water quality and biological effects (such as photosynthesis, decomposition, and nutrient recycling), as acted upon by hydrodynamic factors (including flow, wind, tide, and salinity) to the timing and magnitude of constituent loads supplied from various categories of pollution sources. The assimilative capacity should be related to some specific hydro-meteorological condition such as an 'average' during a selected time span or to cover some range of expected variation in these conditions.

As discussed in Chapter 4, the HSPF model was selected as the watershed and waterbody model. It was run dynamically through the ten-year period (1996-2006) on an hourly time-step.

5.1.1 Climatology

Rainfall, air temperature, wind speed and direction, solar radiation, cloud cover, relative humidity, evaporation, and dew point temperature directly influence the hydrologic balance and receiving water quality within a watershed. Automatic measuring stations, situated in various locations within the watershed, quantify the climatological data to allow for modeling or other analysis. Spatial and temporal distributions of climatological data are important factors in accurately modeling hydrologic flow conditions within the watershed. As a result, these data are perhaps the most important inputs to the hydrologic and water quality models (CDM, 2008).

Rainfall

Rainfall is the predominant factor contributing to the hydrologic balance of a watershed. It is the primary source of surface runoff and baseflow from the watershed to the receiving waters, as well as a direct contributor to the surface of receiving waters. The FDEP obtained a rainfall dataset that combines radar observations from NOAA's National Weather Service Weather Surveillance Radar 88 Doppler (WSR-88Ds) and hourly rainfall observations from an operational *in situ* rain gauge network. The rainfall data were extracted for the Project Area for use in the model.

The FDEP multisensor rainfall dataset was checked against (and supplemented by) the hourly rainfall data obtained from SFWMD for 51 rainfall stations located within Glades, Highlands, Okeechobee, Osceola, Orange, and Polk Counties. The data collected from these stations range from January 1991 to December 2006. **Table 5.1** provides a summary of these stations along with the maximum intensity recorded at each station. **Figure 5.1** illustrates each station location that is near Lake Marian. The CDM, 2008 report contains additional information and describes how the data were used in the model. **Figure 5.2** depicts the daily rainfall. As can be seen on this figure, the period 2003-2005 contained days with rainfall totals of over 4 inches/day. **Figure 5.3** shows the monthly average rainfall. Based on this information, June through September has nearly three times the average rainfall (averaging nearly 6.2 inches) vs. the average rainfall for the months October through May average (averaging 2.3 inches). **Figure 5.4** depicts the annual average rainfall for the years 1996-2006. During this period, the average rainfall was 43.4 inches/year. The years 1998, 1999, 2001, and 2003 could be

considered as average years. The years 2000 and 2006 are dry years, while 1997, 2002, 2004 and 2005 could be considered as wet years.

Table 5.1 Hourly Rainfall Stations

Station	Location (County)	Period of Record		Max. Intensity (in/hr)
		Begin	End	
ALL2R	Osceola	02/19/1998	12/31/2006	2.38
ARS_B0_R	Okeechobee	10/06/1992	12/31/2006	3.29
BASING_R	Okeechobee	11/20/2003	12/31/2006	1.49
BASSETT_R	Okeechobee	06/30/1992	12/31/2006	4.18
BEELINE_R	Orange	04/12/2006	12/31/2006	1.45
CREEK_R	Polk	12/12/2002	12/31/2006	2.72
ELMAX_R	Osceola	08/08/2006	12/31/2006	1.80
EXOTR	Osceola	02/11/1998	12/31/2006	2.88
FLYGW_R	Okeechobee	02/22/2000	12/31/2006	2.63
FLYING_G_R	Okeechobee	01/01/1991	12/31/2006	1.79
GRIFFITH_R	Okeechobee	07/08/2004	12/31/2006	2.26
INDIAN_L_R	Polk	01/25/2003	12/31/2006	1.89
INRCTY_R	Osceola	03/05/2003	12/31/2006	2.32
KENANS1_R	Osceola	12/14/2004	12/31/2006	2.95
KIRCOF_R	Osceola	08/09/2000	12/31/2006	2.55
KISSFS_R	Osceola	07/04/2002	12/31/2006	2.82
KRBNR	Highlands	05/15/1997	12/31/2006	2.69
KREFR	Polk	05/16/1997	12/31/2006	2.69
LOTELA_R	Highlands	12/02/2004	12/31/2006	1.87
MAXCEY_N_R	Osceola	06/20/2006	12/31/2006	1.96
MAXCEY_S_R	Okeechobee	08/04/2006	12/31/2006	1.07
MCARTH_R	Highlands	05/26/2006	12/31/2006	1.14
MOBLEY_R	Okeechobee	09/03/1992	12/31/2006	3.30
OPAL_R	Okeechobee	10/23/1992	12/31/2006	3.21
PC61_R	Okeechobee	04/17/2002	12/31/2006	2.08
PEAVINE_R	Okeechobee	07/05/2004	12/31/2006	4.12
PINE_ISL_R	Osceola	07/21/2004	12/31/2006	2.34
ROCK_K_R	Okeechobee	11/23/2003	12/31/2006	3.06
RUCKGW_R	Okeechobee	02/22/2000	12/31/2006	2.59
RUCKSWF_R	Okeechobee	01/01/1991	12/31/2006	4.73
S59_R	Osceola	12/26/1995	12/31/2006	2.91
S61W	Osceola	10/20/1992	12/31/2006	2.92
S65A_R	Polk	01/30/2003	11/05/2004	1.91
S65C_R	Okeechobee	01/01/1991	11/12/1991	1.41
S65CW	Okeechobee	10/20/1992	12/31/2006	3.45

Table 5.1 SFWMD Hourly Rainfall Stations (Cont.)

Station	Location (County)	Period of Record		Max. Intensity (in/hr)
		Begin	End	
S65D_R	Okeechobee	02/23/1995	04/02/2002	2.37
S65DWX	Okeechobee	02/23/2000	12/31/2006	2.44
S68_R	Highlands	03/18/1997	12/31/2006	2.71
S75_R	Glades	03/18/1997	12/31/2006	2.69
S75WX	Glades	09/01/2002	12/31/2006	4.02
S82_R	Highlands	03/18/1997	12/31/2006	1.93
S83_R	Highlands	03/18/1997	12/31/2006	2.87
SEBRNG_R	Highlands	11/30/2004	12/31/2006	1.57
SHING.RG	Orange	03/12/1992	12/31/2006	3.16
SNIVELY_R	Polk	07/14/2004	12/31/2006	1.86
TAYLC_R	Okeechobee	09/18/1995	12/31/2006	8.10
TICK_ISL_R	Polk	01/16/2001	12/31/2006	2.43
TOHO2_R	Osceola	06/25/1996	12/31/2006	2.82
TOHO10_R	Osceola	06/24/1999	12/31/2006	2.50
TOHO15_R	Osceola	07/02/1999	12/31/2006	2.39
WRWX	Polk	04/16/1997	12/31/2006	3.04

Figure 5.1 Hourly Rainfall Stations near Lake Marian

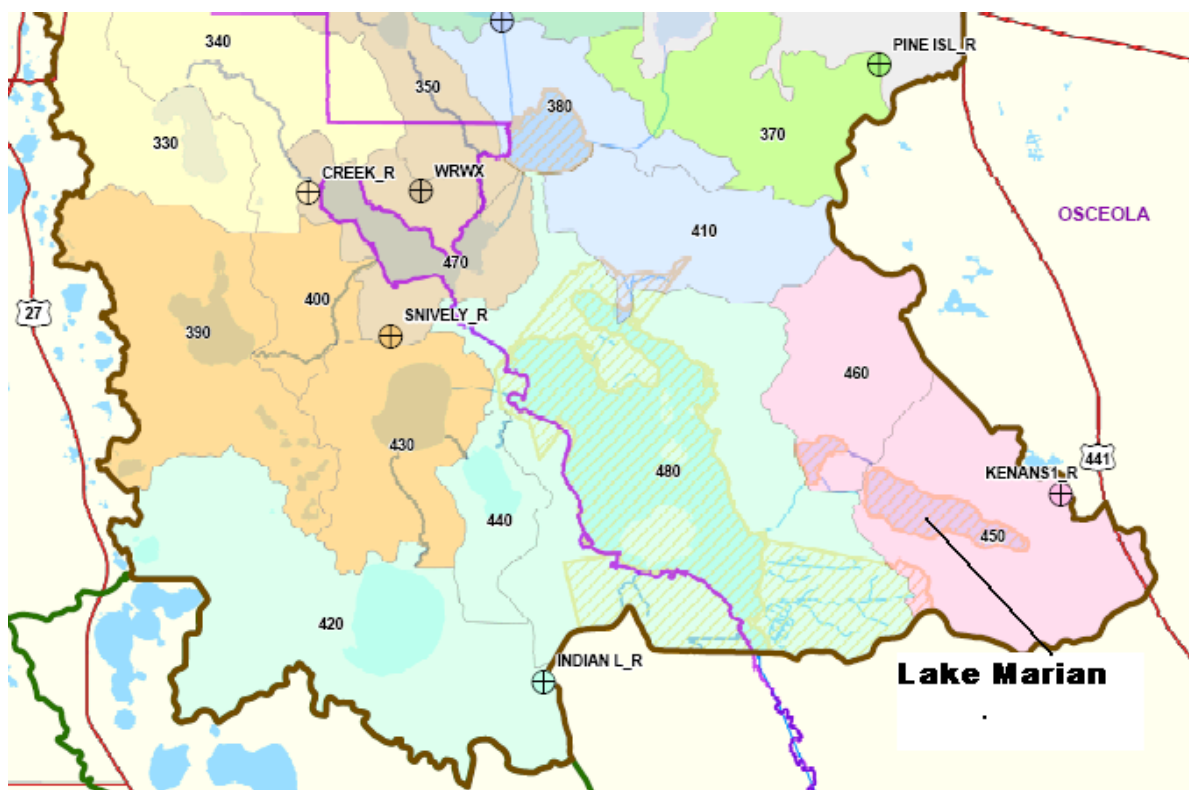


Figure 5.2 Daily Rainfall used in model (1996-2006)

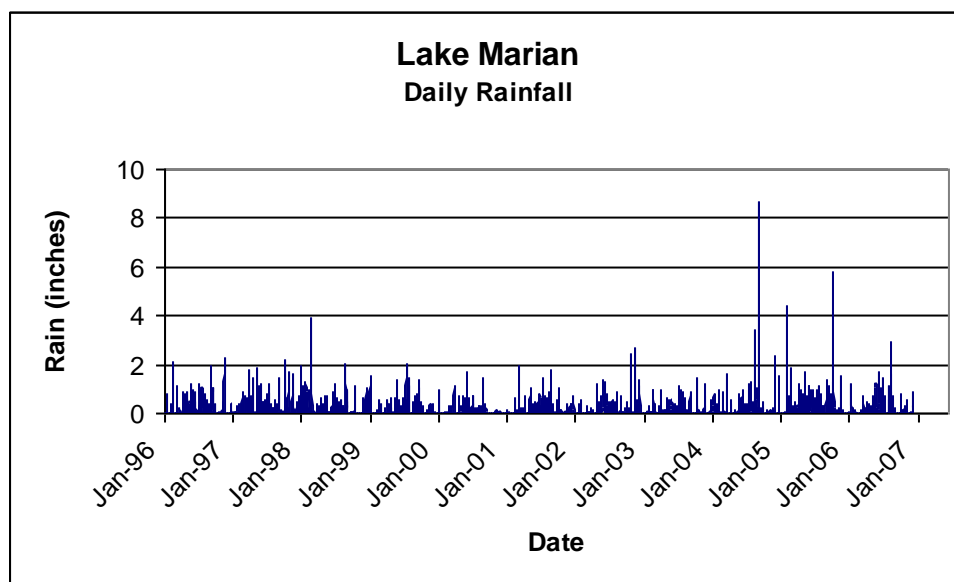


Figure 5.3 Monthly Average Rainfall from Model Dataset

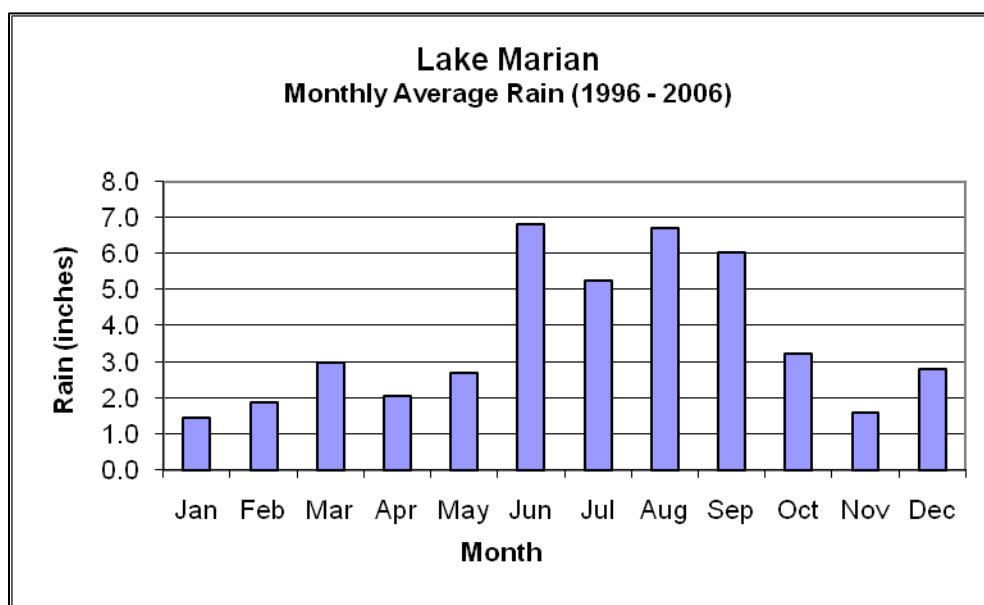
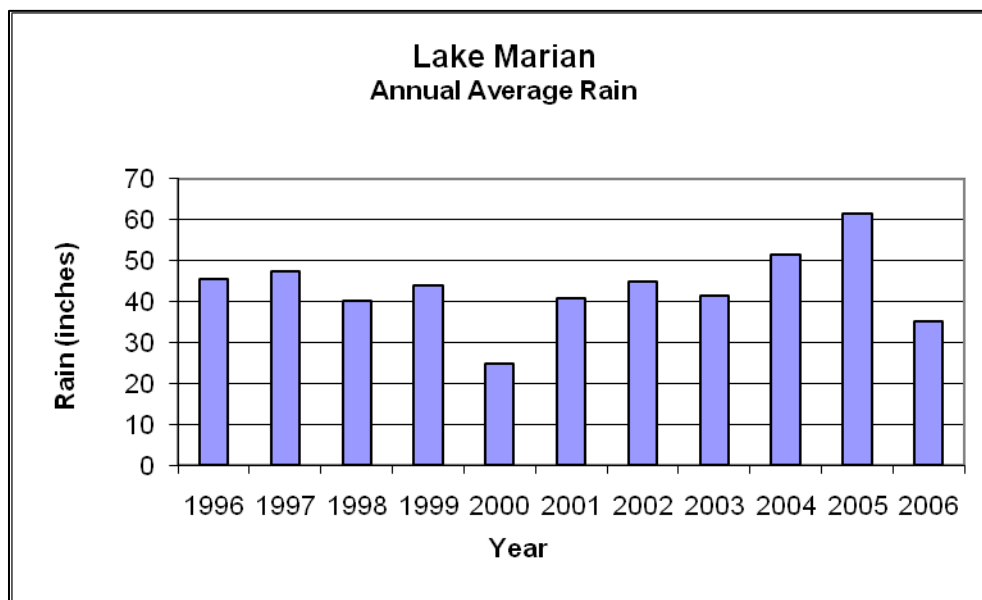


Figure 5.4 Annual Average Rainfall from Model Dataset (1996-2006)



Evaporation/Evapotranspiration

Evaporation data and evapotranspiration (ET) rates are important factors in determining hydrologic balances and modeling, since they provide estimates of hydrologic losses from land surfaces and waterbodies within the watershed. As a result, daily Class A pan evaporation data and potential ET data were obtained from 14 monitoring stations located within Okeechobee, Osceola, and Polk Counties. The data were downloaded from the SFWMD database DBHYDRO, and the monitoring dates range from January 1991 to December 2006 (**Table 5.2**).

Figure 5.5 illustrates the station locations closest to the Lake Marian watershed. The CDM, 2008 report contains additional information and describes how the data were used in the model.

Figure 5.5 SFWMD Pan Evaporation and Potential Evapotranspiration Monitoring Stations near Lake Marian

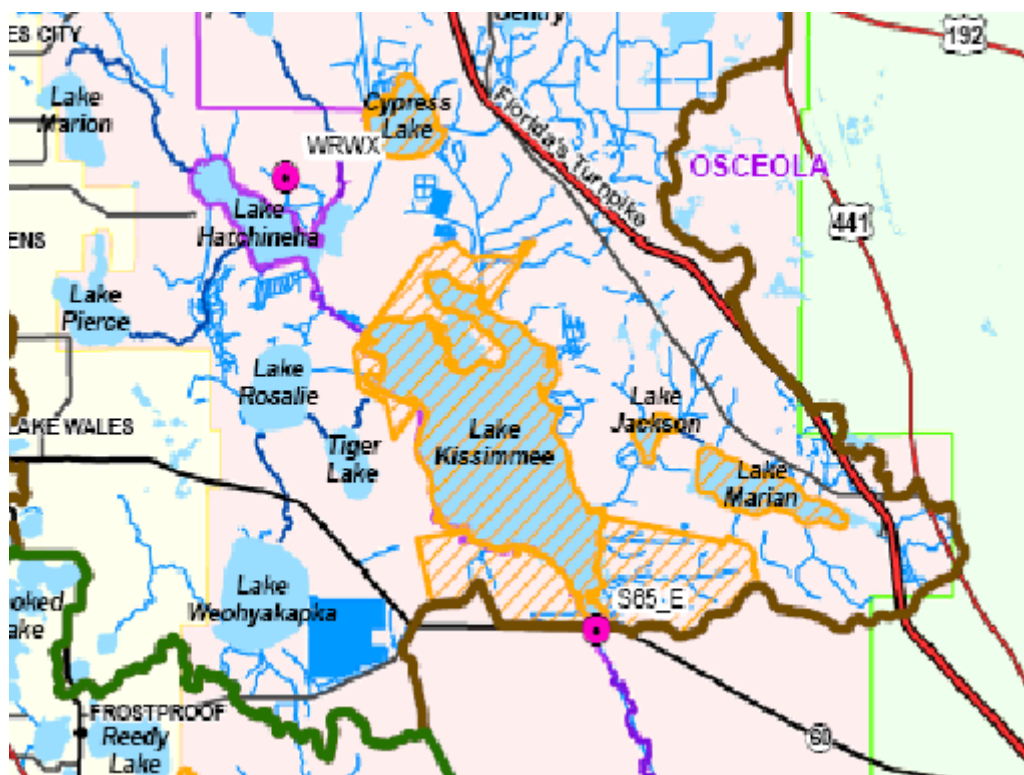


Table 5.2 SFWMD Pan Evaporation and Potential Evapotranspiration Monitoring Stations

Station	Period of Record		Data Type
	Begin	End	
ARCHBO 2	01/01/1991	11/30/1994	Pan Evaporation
BIRPMWS	01/01/1998	12/31/2006	Potential Evapotranspiration
BIRPSW	01/01/2002	12/31/2006	Potential Evapotranspiration
BIRPWS2	01/01/2002	12/31/2006	Potential Evapotranspiration
EVP376NE	05/01/2005	12/31/2006	Pan Evaporation
KISS.FS_E	01/01/1991	04/30/1999	Pan Evaporation
L ALF EX_E	01/01/1991	11/30/1998	Pan Evaporation
OKEE FIE_E	01/01/1991	04/30/2005	Pan Evaporation
S65C_E	01/01/1991	09/13/1992	Pan Evaporation
S65CW	10/21/1992	12/31/2006	Potential Evapotranspiration
S65DWX	02/23/2000	12/31/2006	Potential Evapotranspiration
S65_E	01/01/1991	12/31/2006	Pan Evaporation
S75WX	09/02/2002	12/31/2006	Potential Evapotranspiration
WRWX	04/17/1997	12/31/2006	Potential Evapotranspiration

Other Climatological Data

Daily air temperature, solar radiation, and wind speed data were obtained from eight monitoring stations located within Okeechobee, Osceola, and Polk Counties, as summarized in **Table 5.3** and shown on **Figure 5.6**. The data were downloaded from DBHYDRO and range from October 1992 to December 2006. Daily cloud cover and dew point temperature data from five monitoring stations were obtained from NOAA.

Table 5.3 SFWMD Air Temperature, Solar Radiation, and Wind Speed Monitoring Stations

Station	Period of Record	
	Begin	End
BIRPMWS	01/01/1998	12/31/2006
BIRPSW	01/01/2002	12/31/2006
BIRPWS2	01/01/2002	12/31/2006
L001	08/04/1994	12/31/2006
S61W	10/20/1992	12/31/2006
S65CW	10/20/1992	12/31/2006
S65DWX	02/23/2000	12/31/2006
WRWX	04/17/1997	12/31/2006

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5.2 Model Calibration/Validation

Hydrologic Calibration/Validation

The HSPF model for the Lake Marian watershed was calibrated using the simulation period of January 1997 through December 2000. Model validation (years 2001-2006) was used to apply the calibrated model to a different time period without changing the calibrated hydrologic and hydraulic parameters. This step is taken to further confirm that those calibrated hydrologic parameters are still applicable to the new time period of model application and statistically similar results are expected. Additionally both calibration and validation comparisons are “point to point” in that only model results from the day corresponding to the same day as the measured data are used for assessing calibration and validation. The model validation period for this Project was selected as the period 2001 through 2006, with one dry, two wet, and three average years. The full year of 1996 simulation was used as the model start-up (initialization) period, which was not used in the comparison between measured and simulated stream flows and lake stages. Instead, this was considered as an antecedent period for the model to generate reasonable values of soil moisture storage that were not heavily dependent upon the initial model conditions.

Because the study area is largely pervious land, the calibration process focused on the development of appropriate pervious area hydrologic parameters. Initial parameter values were determined based on previous modeling efforts (CDM, 2003). Values were then adjusted to improve the match between measured and modeled stream flows. Parameter values were largely maintained within a range of possible values based on CDM's previous experience with the HSPF hydrologic model and on BASINS Technical Note 6 [Hartigan, 1983 (A); Hartigan, 1983 (B); NVPDC, 1983; NVPDC, 1986; CDM, 2002; EPA, 2000].

Besides the 16 major hydraulic control structures discussed in Section 4.2.5 of the CDM, 2008 report, many local small hydraulic control structures throughout the Reedy Creek and Boggy Creek watersheds in the Upper Kissimmee Planning Unit were identified by other studies (URS Greiner, 1998 and USGS, 2002). It appeared that flow stations with a considerable amount of flow measurements in the Project Area were somewhat affected by the hydraulic control structures. Ideally, flow stations with a considerable amount of flow measurements that are not affected by any hydraulic control structures should be selected for initial hydrological model calibrations. To minimize the effect of hydraulic control structures, the initial calibration focused on three gauged sub-basins in the northern part of the study area in the Upper Kissimmee Planning Unit (Reedy Creek, Shingle Creek, and Boggy Creek), which are not largely influenced by hydraulic control structures. Parameters were established for these sub-basins, which provided a reasonable match to measured data. These parameter values and relationships to land use were then uniformly applied to all the sub-basins in the planning units. Furthermore, sub-basin-specific parameters such as LZSN, UZSN, and INFILT were developed based on local hydrologic soil group information.

Further flow calibrations at the control structures were completed by adjusting control structure flow rates and lake volumes, (in the HSPF FTable) when appropriate. A detailed discussion of this method is included in Section 4.5 of the CDM, 2008 report.

The comparison of measured and model-predicted stream flow values considered a number of factors that include: comparison of total flow volume for the entire simulation period and comparison of measured and modeled annual stream flow volume. The following

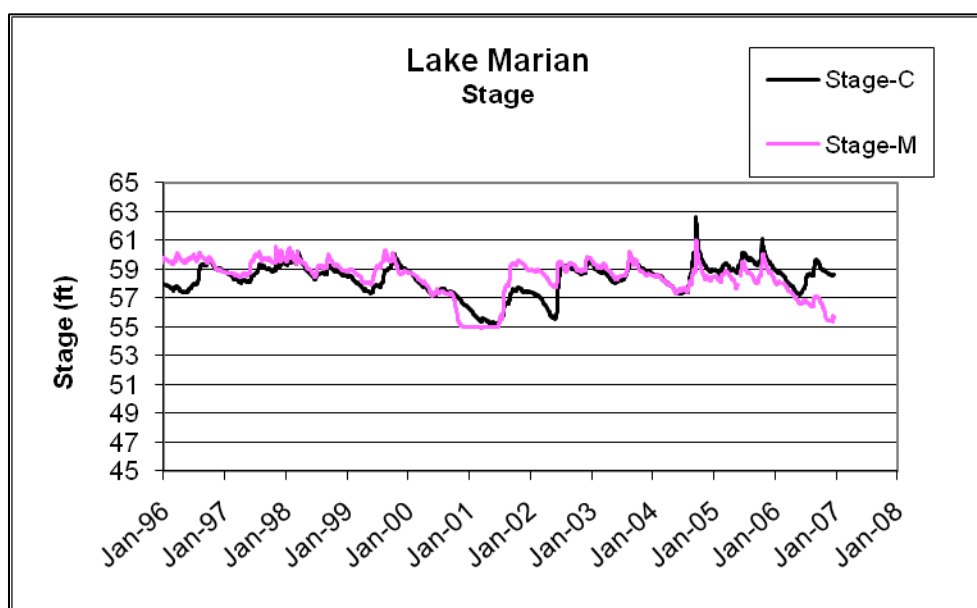
methodologies were used to determine how well the simulated data compare to the measured data:

- Visual inspection of measured and modeled time series flow graphs: This method graphically compares the pattern of measured and modeled flows with respect to peak flows, hydrograph shapes, and comparison of high and low flow periods.
- “Box and whisker” plots graphically comparing the median and distribution of the observed data and the simulated concentrations;
- Tukey-Kramer comparison of means for the observed data vs. simulated results using the JMP version 8.0 software package.
- Stage Plots: Plots of modeled versus measured stages were developed for all the lakes with control structures and impaired WBIDs, where measured data are available.

Details of the hydrologic calibration/validation values and comparison of modeled and measured stream flows and lake stages for each planning unit are presented in Section 4 of the CDM, 2008 report.

The results for calibration (1997-2000) and validation (2001-2006) for stage in Lake Marian are depicted on **Figure 5.7** below.

Figure 5.7 Measured and Simulated Lake Daily Stage (1996 – 2006)



As can be seen on **Figure 5.7**, the model over-predicted the stage during some periods and under predicted stage at other times. A source of differences could be inadequate estimates of ground water contribution. The monthly average stage calibration results (**Figure 5.8** and **Table 5.4**) comparing model predictions to the measured data indicate the means are not significantly different at an alpha of 0.05. The monthly average stage validation results (**Figure 5.9** and **Table 5.5**) comparing model predictions to the measured data indicate the means are not significantly different at an alpha of 0.05. These results indicate that the model predictions of lake stage are acceptable.

Figure 5.8 Calibration Results for Monthly Average Measured and Simulated Lake Stage (1997-2000)

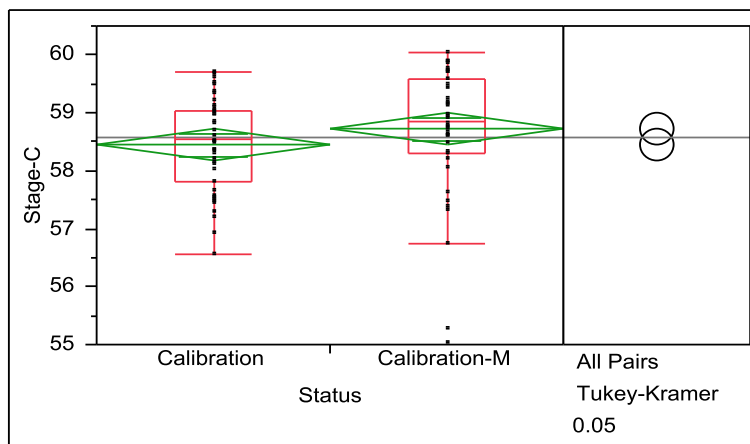


Table 5.4 Calibration Monthly Average Stage JMP Means Comparison (1997 – 2000)

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
	q*	Alpha
	1.98552	0.05
Abs(Dif)-LSD		
Calibration-M	-0.3856	-0.11383
Calibration	-0.11383	-0.3856
Positive values show pairs of means that are significantly different.		
Level	Mean	
Calibration-M	A	58.7
Calibration	A	58.4
Levels not connected by same letter are significantly different.		

Figure 5.9 Validation Results for Monthly Average Measured and Simulated Lake Stage (2001 – 2006)

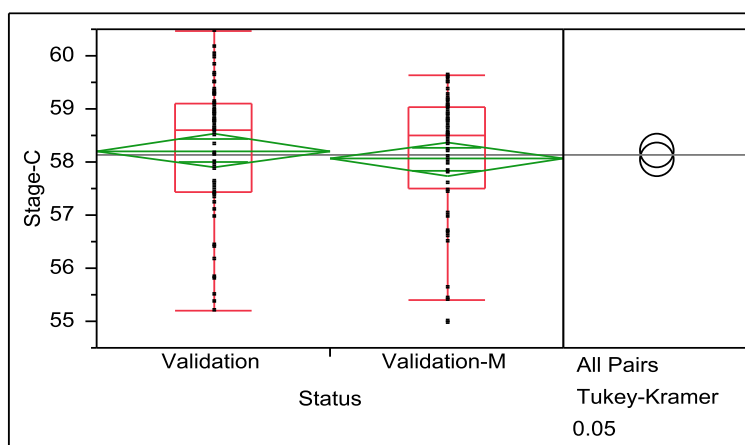


Table 5.5 Validation Monthly Average Stage JMP Means Comparison (2001 – 2006)

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
	q*	Alpha
	1.97681	0.05
Abs(Dif)-LSD	Validation	Validation-M
Validation	-0.434	-0.27459
Validation-M	-0.27459	-0.434
Positive values show pairs of means that are significantly different.		
Level		Mean
Validation	A	58.21
Validation-M	A	58.05
Levels not connected by same letter are significantly different.		

As can be seen on **Figure 5.10** for daily temperature calibration/validation, the HSPF model reasonably predicts daily temperature. There was one measured result less than 5 degrees Centigrade, this value was not included in the statistical analysis of model results. The daily temperature calibration results (**Figure 5.11** and **Table 5.6**) comparing model predictions to the measured data indicate the means are not significantly different at an alpha of 0.05. The daily temperature validation results (**Figure 5.12** and **Table 5.7**) comparing model predictions to the measured data indicate the means are not significantly different at an alpha of 0.05. These results indicate that the model predictions of lake temperature are acceptable.

Figure 5.10 Measured and Simulated Daily Temperature (1996 – 2006)

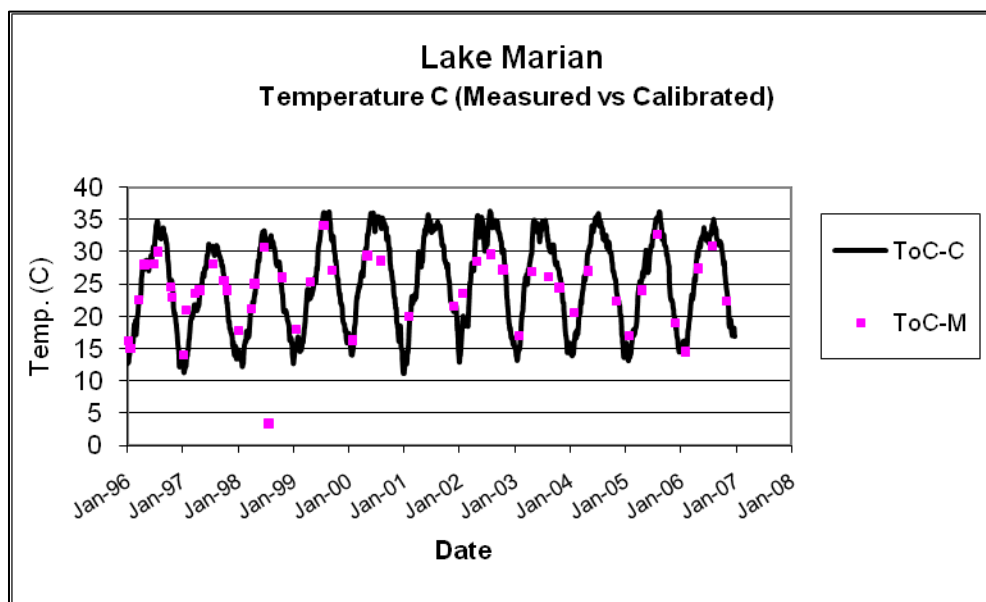


Figure 5.11 Calibration Results for Daily Measured and Simulated Lake Temperature (1997 – 2000)

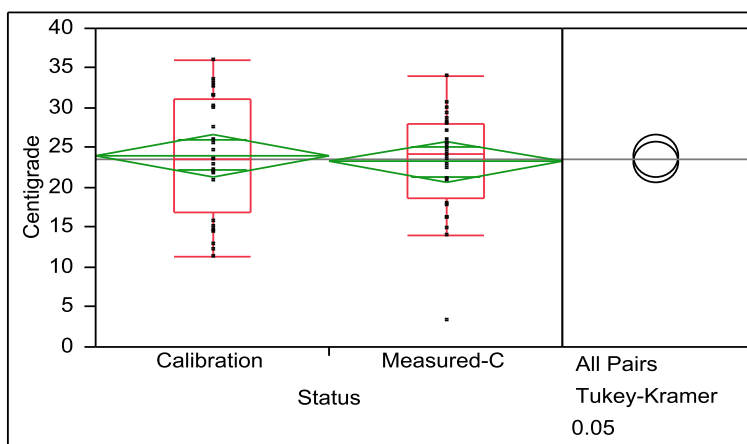


Table 5.6 Calibration Daily Temperature JMP Means Comparison (1997 – 2000)

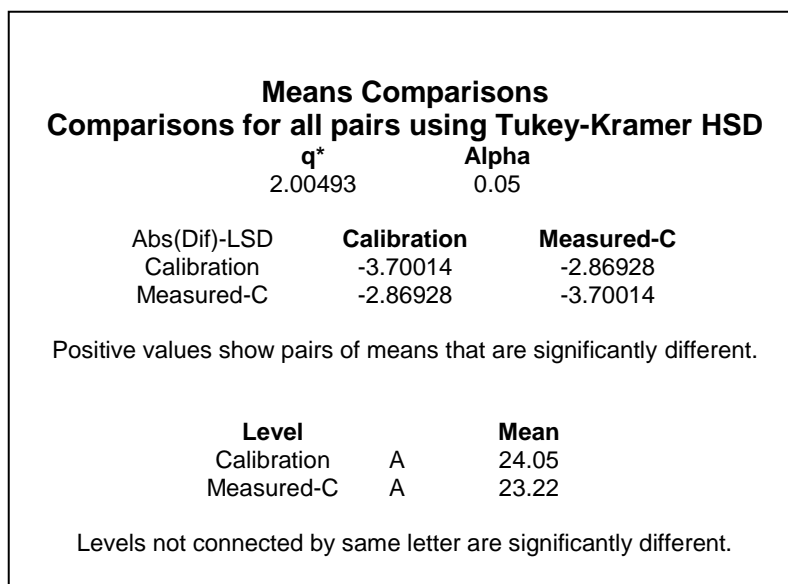
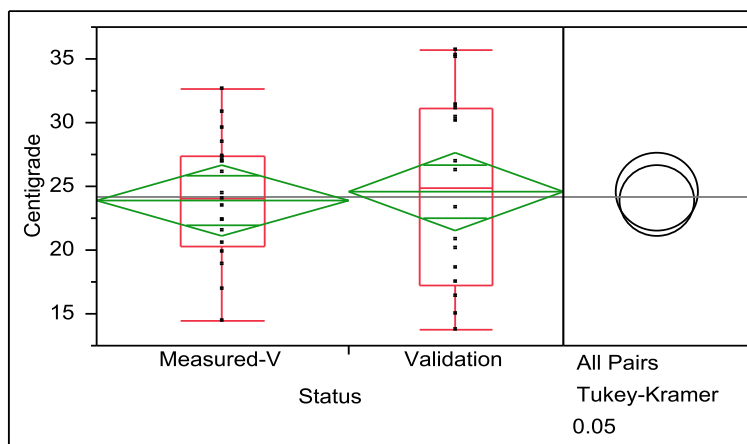


Figure 5.12 Validation Results for Daily Measured and Simulated Lake Temperature (2001 – 2006)



**Table 5.7 Validation Daily Temperature JMP Means Comparison
(2001 – 2006)**

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
	q*	Alpha
	2.02621	0.05
Abs(Dif)-LSD		
Validation	-4.26421	-3.44314
Measured-V	-3.44314	-3.94789
Positive values show pairs of means that are significantly different.		
	Level	Mean
Validation	A	24.58
Measured-V	A	23.91
Levels not connected by same letter are significantly different.		

Table 5.8 HSPF Simulated Annual Water Budget for Lake Marian

Year	Baseflow	Interflow	Runoff	Rainfall	Total Inflow	ET	Outflow	Change
	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft	ac-ft
1996	8031	10777	1458	25079	45344	-28385	-11204	5755
1997	6801	9200	1065	26909	43975	-29067	-11335	3573
1998	7891	15086	1429	23175	47581	-28901	-24798	-6118
1999	8667	11216	1277	24533	45692	-29502	-13140	3050
2000	1743	1213	401	13175	16533	-30762	-897	-15126
2001	5963	5945	705	20351	32965	-27549	0	5416
2002	9488	14883	1104	24534	50008	-30027	-7294	12687
2003	9385	7863	873	23596	41717	-29784	-16277	-4343
2004	11132	20534	15435	29220	76321	-30745	-44076	1500
2005	16635	24369	9388	36205	86598	-31246	-54745	607
2006	5296	9825	1600	19494	36215	-31235	-8319	-3340
AVG97-06	8300	12013	3328	24119	47761	-29882	-18088	-209
Percent	42.5		7.0	50.5	100	62.3	37.7	

Table 5.8 depicts the model generated water budget for the lake. Surface runoff, interflow, and baseflow generate 23,641 ac-ft/yr, or 49.5% of the total inflow. Direct rainfall on the lake of 24,119 ac-ft/yr makes up 50.5% of the total inflow of water to the lake.

Based on the model, the normal pool volume for the lake is 46,819 ac-ft. The annual average mean outflow is estimated as 18,088 ac-ft/yr. The mean residence time of a lake can be estimated as:

Residence time (years) = lake volume (acre-ft) / mean outflow (acre-ft/yr).

In this case, residence time is 2.6 years.

Water Quality Calibration/Validation

Table 5.9 presents input parameters that include assigned potency factors, interflow concentrations, and baseflow concentrations. For values showing ranges, the lower end of the ranges are applicable for undeveloped areas (e.g., forest, wetland), whereas the higher end of the ranges are applicable for agricultural areas.

Table 5.9 Land-Based Water Quality Input Parameter Values

HSPF Input Parameter	Water Quality Constituent						
	Ortho P	Ammonia N	Nitrate N	CBOD	Refractory Organic N	TP	TN
Interflow Concentration (mg/l)	0.03 - 0.22	0.03 - 0.08	0.20 - 0.63	1.5 - 19	0.7 - 1.2	0.04 - 0.39	1.0 - 2.8
Baseflow Concentration (mg/l)	0.02 - 0.04	0.02 - 0.05	0.13 - 0.25	1.5 - 3.0	0.6 - 0.8	0.03 - 0.07	0.8 - 1.2
Potency Factor (lb/ton sediment)	5.4 - 6.1	4.1	23 - 25	350	23.8	8.6 - 9.3	52 - 53

Based on values in **Table 5.9**, typical results for average annual constituent loads for various land use types and soil groups are presented in **Table 5.10**. The table shows a range of values, which reflect the differences associated with a variety of soil types (e.g., “A” soils generating less runoff than “D” soils). The values shown in the table are consistent with respect to loads estimated or measured in other studies.

Table 5.10 Average Annual Land-Based Loading by Land Use Type and Soil Group

	Soil Group	Average Annual Loads (lb/ac/yr)							
		Ortho P	Ammonia N	Nitrate N	CBOD	Refractory Organic N	TSS	Total P	Total N
Commercial / Industrial	A	1.03	0.7	4.3	60	4.4	330	1.58	11.9
	B	1.05	0.7	4.3	61	4.4	334	1.61	12.0
	C	1.07	0.8	4.4	62	4.5	338	1.63	12.2
	D	1.09	0.8	4.5	63	4.5	344	1.66	12.3
Cropland / Improved Pasture	A	0.18	0.1	0.8	14	2.4	1	0.30	3.9
	B	0.49	0.3	1.8	39	3.4	48	0.84	7.0
	C	0.75	0.4	2.7	58	4.4	111	1.28	9.9
	D	1.22	0.7	4.5	90	6.1	264	2.05	15.1
High Density Residential	A	0.69	0.5	3.0	41	3.6	206	1.07	8.8
	B	0.75	0.5	3.1	45	3.7	215	1.16	9.2
	C	0.80	0.6	3.3	48	3.8	226	1.24	9.7
	D	0.84	0.6	3.5	52	3.8	242	1.31	10.0
Low Density Residential	A	0.24	0.2	1.2	17	2.5	42	0.39	4.6
	B	0.35	0.3	1.5	26	2.7	57	0.58	5.5
	C	0.44	0.3	1.8	33	2.9	77	0.74	6.5
	D	0.53	0.4	2.1	41	3.0	104	0.90	7.2
Medium Density Residential	A	0.41	0.3	1.9	26	2.9	104	0.65	6.2
	B	0.50	0.4	2.1	34	3.1	116	0.80	6.9
	C	0.58	0.4	2.4	40	3.3	132	0.94	7.7
	D	0.65	0.5	2.6	46	3.3	156	1.07	8.3
Forest / Rangeland	A	0.05	0.0	0.3	4	1.4	0	0.08	1.9
	B	0.08	0.1	0.5	6	1.7	8	0.13	2.5
	C	0.12	0.1	0.7	8	1.9	20	0.19	3.1
	D	0.18	0.2	1.0	12	2.1	42	0.29	3.8
Unimproved Pasture	A	0.11	0.1	0.7	8	2.0	0	0.18	3.1
	B	0.20	0.2	1.0	16	2.2	18	0.34	4.0
	C	0.30	0.2	1.4	23	2.6	42	0.51	5.2
	D	0.43	0.3	2.0	32	2.9	87	0.72	6.5
Wetlands	A	---	---	---	---	---	---	---	---
	B	---	---	---	---	---	---	---	---
	C	---	---	---	---	---	---	---	---
	D	0.05	0.1	0.4	4	1.4	9	0.09	2.1

A discussion of the development of model input parameter values is presented below. The complete set of HSPF calibration values and coefficients used in the modeling are listed in **Appendix C**.

Water temperature is not a cause of impairment, but it has an effect on water quality processes related to impairments. DO concentrations tend to be lower in the summer months when the water temperature is high, in part because the saturation DO for water decreases as temperature increases, and in part because processes that deplete DO (BOD decay, sediment oxygen demand) are also affected by water temperature. The modeling of water temperature in the reaches uses a number of meteorological time series (as discussed earlier), and a set of four input parameters.

These parameters were all initially set at the default value, and one of the values was modified in the calibration process. Results showed that the water temperature simulations accurately captured the seasonal variability of the water temperature in the receiving waters.

As discussed in Chapter 4, in the evaluation of nutrients and phytoplanktonic algae (as chlorophyll *a*), the HSPF model accounts for the following water quality constituents:

- Organic nitrogen (organic N);
- Ammonia nitrogen (ammonia N);
- Nitrite + nitrate nitrogen (nitrate N);
- Organic phosphorus (organic P);
- Inorganic phosphorus (inorganic P); and
- Phytoplanktonic algae (chlorophyll *a*).

Organic N and organic P in the model are associated with several water quality constituents, which include ultimate CBOD, phytoplankton, and refractory organics that are the result of the death of algae.

The key processes that affect the model simulation of phytoplankton concentration in receiving waters include the following:

- Phytoplankton growth;
- Phytoplankton respiration;
- Phytoplankton death; and
- Phytoplankton settling.

Phytoplankton growth is modeled based on a specified maximum growth rate, which is adjusted by the model based on water temperature, and is limited by the model based on available light and inorganic N and P. Similarly, death and respiration are modeled based on specified rates that are adjusted for water temperature. A higher death rate may be applied by the model under certain conditions (*e.g.*, high water temperature, high chlorophyll *a* concentration). Settling is modeled based on a constant settling rate. Growth increases the concentration of phytoplankton, whereas the other processes reduce the concentration of phytoplankton.

The key processes that affect the model simulation of nitrogen concentrations in receiving waters include the following:

- First-order decay of BOD (organic N associated with BOD is converted to ammonia N in this process);
- BOD settling (organic N associated with BOD is lost to the lake sediments);
- Phytoplankton growth (inorganic N is converted to phytoplankton N);
- Phytoplankton respiration (phytoplankton N is converted to ammonia N);

- Phytoplankton death (phytoplankton N is converted to BOD and/or refractory organic N);
- Phytoplankton settling (phytoplankton N is lost to the lake sediments);
- Refractory organic N settling to lake sediments;
- Nitrification (conversion of ammonia N to nitrate N); and
- Sediment flux (ammonia N is released from sediment to overlying water).

Ultimately, the rate at which nitrogen is removed from the receiving water depends on the rate at which inorganic N is converted to organic N (by phytoplankton growth) and the rate at which the organic N forms (as BOD, as refractory organic N, and as phytoplankton N) settle to the lake sediments.

The key processes that affect the model simulation of phosphorus concentrations in the lake include the following:

- First-order decay of BOD (organic P associated with BOD is converted to inorganic P in this process);
- BOD settling (organic P associated with BOD is lost to the lake sediments);
- Phytoplankton growth (inorganic P is converted to phytoplankton P);
- Phytoplankton respiration (phytoplankton P is converted to inorganic P);
- Phytoplankton death (phytoplankton P is converted to BOD and/or refractory organic P);
- Phytoplankton settling (phytoplankton P is lost to the lake sediments);
- Refractory organic P settling to lake sediments; and
- Sediment flux (inorganic P is released from sediment to overlying water).

Ultimately, the rate at which phosphorus is removed from the lake water depends on the rate at which inorganic P is converted to organic P (by phytoplankton growth) and the rate at which the organic P forms (as BOD, as refractory organic P, and as phytoplankton P) settle to the lake sediments.

Waterbodies with long mean residence times (months or years), allow substantial time and relatively quiescent conditions for phytoplankton growth. In contrast, these processes are expected to have little impact in free-flowing stream reaches with short residence times (a day or less) and relatively turbulent conditions. However, it is possible to see high phytoplankton levels in streams during dry weather periods, if the stream has some areas of standing water.

For DO, the key processes affecting concentrations in the reaches include the following:

- Reaeration;
- Phytoplankton growth and respiration;

- BOD decay;
- Nitrification; and
- Sediment oxygen demand (SOD).

Reaeration is a process of exchange between the water and the overlying atmosphere, which typically brings oxygen into the receiving water (unless the receiving water DO concentration is above saturation levels). In the long-term, phytoplankton growth and respiration typically provides a net DO benefit (*i.e.*, introduces more DO through growth than is depleted through respiration). The other three processes take oxygen from the receiving water. Results of the modeling suggest that reaeration and SOD are often the key processes in the overall DO mass balance, though the other processes may be important in lakes that have relatively high loadings.

The model simulates flows and associated loads from the tributary area into the Lake Marian reach (RCHRES 450) to perform HSPF water quality calculations. Simulations included concentrations of water quality constituents including phytoplankton, and various forms of nitrogen and phosphorus. During HSPF calibration, water quality input parameters that represent the physical and biological processes in the lake were set so that the simulated concentrations were comparable to the available measured water quality data for Lake Marian.

The daily TN calibration results are depicted on **Figure 5.13** and the annual means on **Figure 5.14**. While the daily and annual average results indicate that the model is underestimating the total nitrogen concentrations in the lake, **Figure 5.15** and **Table 5.11** comparing model annual average calibration predictions to the measured data (point to point) indicate the means are not significantly different at an alpha of 0.05. The annual average TN validation results (**Figure 5.16** and **Table 5.12**) comparing model predictions to the measured data indicate the means are not significantly different at an alpha of 0.05. These results indicate that the model predictions of lake TN are acceptable for predicting annual averages.

Figure 5.13 Lake Marian Total Nitrogen Daily Average Measured Data and Calibration/Validation Results (1996 - 2006)

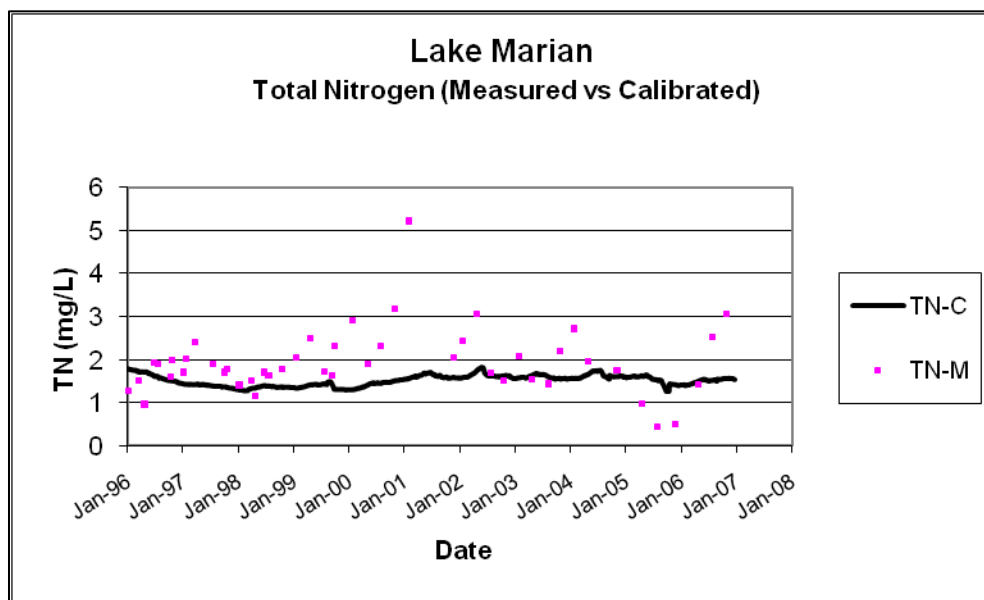


Figure 5.14 Lake Marian Total Nitrogen Annual Average Measured Data (1996 – 2009) and Calibration/Validation Results (1996 - 2006)

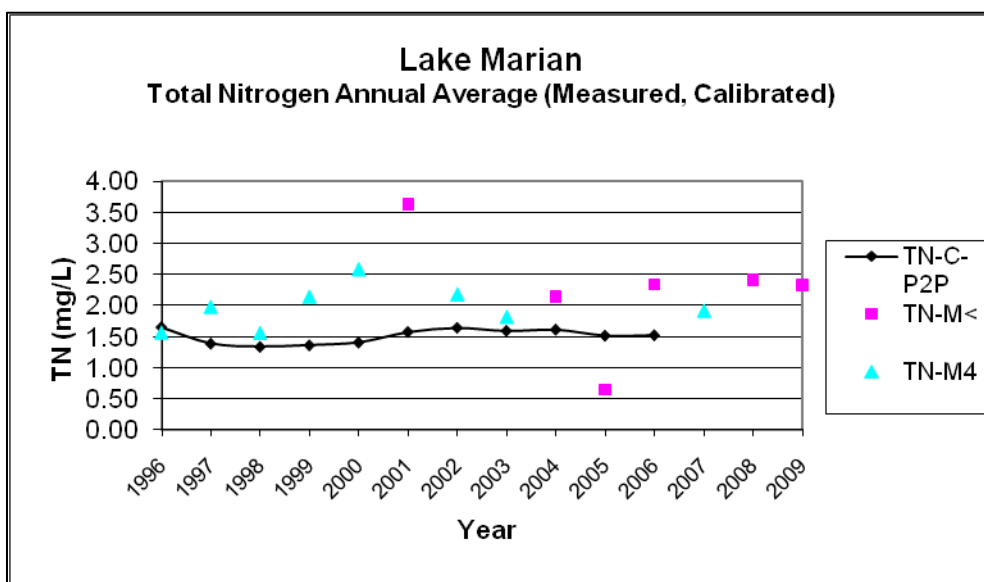


Figure 5.15 Lake Marian Total Nitrogen Means Comparison for Annual Average Measured Data and Calibration Results (1997 - 2000)

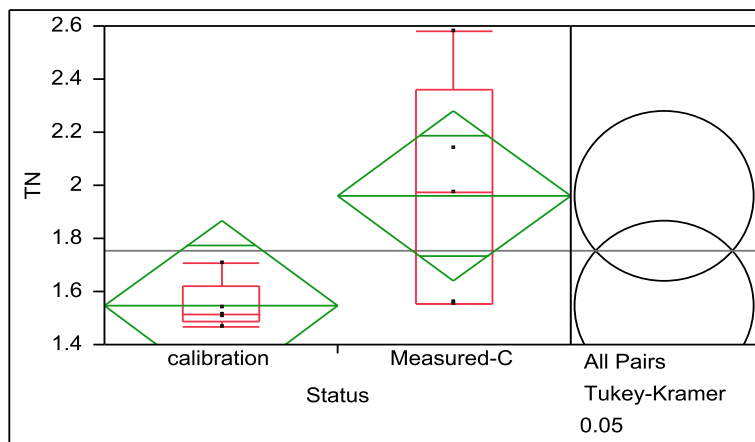


Table 5.11 Lake Marian Total Nitrogen Means Comparison for Annual Average Measured Data and Calibration Results (1997 - 2000)

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
Abs(Dif)-LSD	Measured-C	calibration
Measured-C	-0.45491	-0.04092
calibration	-0.04092	-0.45491
Positive values show pairs of means that are significantly different.		
Level	Mean	
Measured-C	A	1.96
calibration	A	1.55

Figure 5.16 Lake Marian Total Nitrogen Means Comparison for Annual Average Measured Data and Validation Results (2001 - 2006)

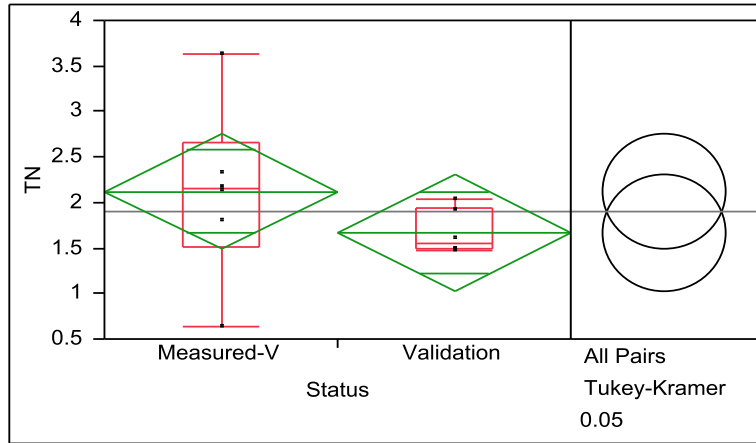


Table 5.12 Lake Marian Total Nitrogen Means Comparison for Annual Average Measured Data and Validation Results (2001 - 2006)

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
	q*	Alpha
	2.22813	0.05
Abs(Dif)-LSD	Measured-V	Validation
Measured-V	-0.9009	-0.44979
Validation	-0.44979	-0.9009
Positive values show pairs of means that are significantly different.		
Level	Mean	
Measured-V	A	2.12
Validation	A	1.67

The daily TP calibration results are depicted on **Figure 5.17** and the annual means on **Figure 5.18**. On **Figure 5.17** it can be seen that the TP jumps up in late 2004. Comparing this time frame to **Figures 5.2** and **5.4** (rainfall) and **5.7** (lake stage) it can be seen that lake stage went up by nearly three feet (measured data) in response to unusually large rainfall events. While the modeled TN concentrations did not appear to respond to this rainfall the TP loading estimated by the model increased dramatically. However, the daily and annual average results

for the ten year period indicate that the model is underestimating the total phosphorus concentrations in the lake. **Figure 5.19** and **Table 5.13** comparing the model annual average calibration predictions to the measured data (point to point) indicate the means are not significantly different at an alpha of 0.05. The annual average TP validation results (**Figure 5.20** and **Table 5.14**) comparing model predictions to the measured data indicate the means are not significantly different at an alpha of 0.05. These results indicate that the model predictions of lake TP are acceptable for predicting annual averages.

Figure 5.17 Lake Marian Total Phosphorus Daily Average Measured Data and Calibration/Validation Results (1996 - 2006)

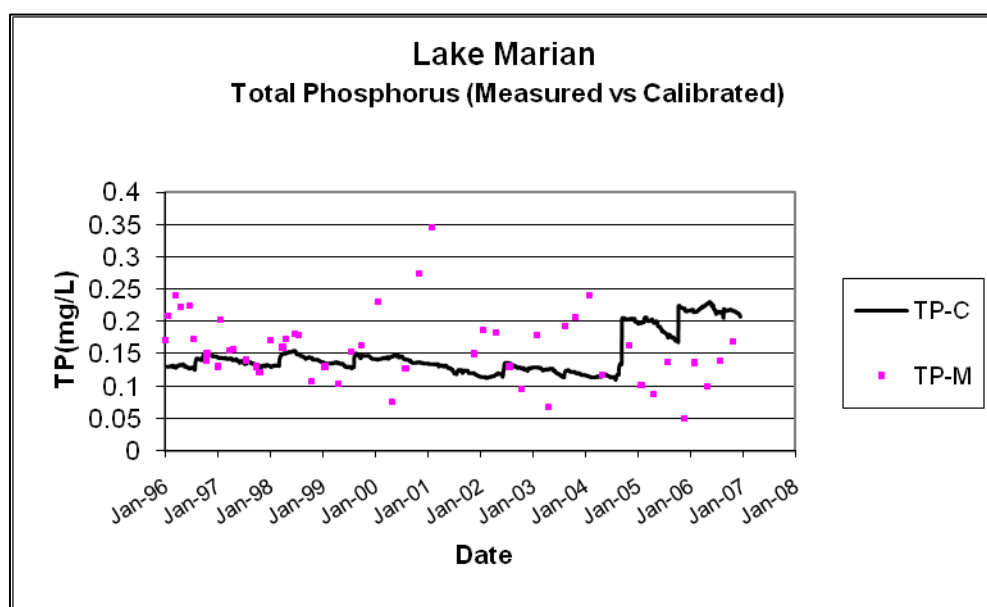


Figure 5.18 Lake Marian Total Phosphorus Annual Average Measured Data (1996 – 2009) and Calibration/Validation Results (1996 - 2006)

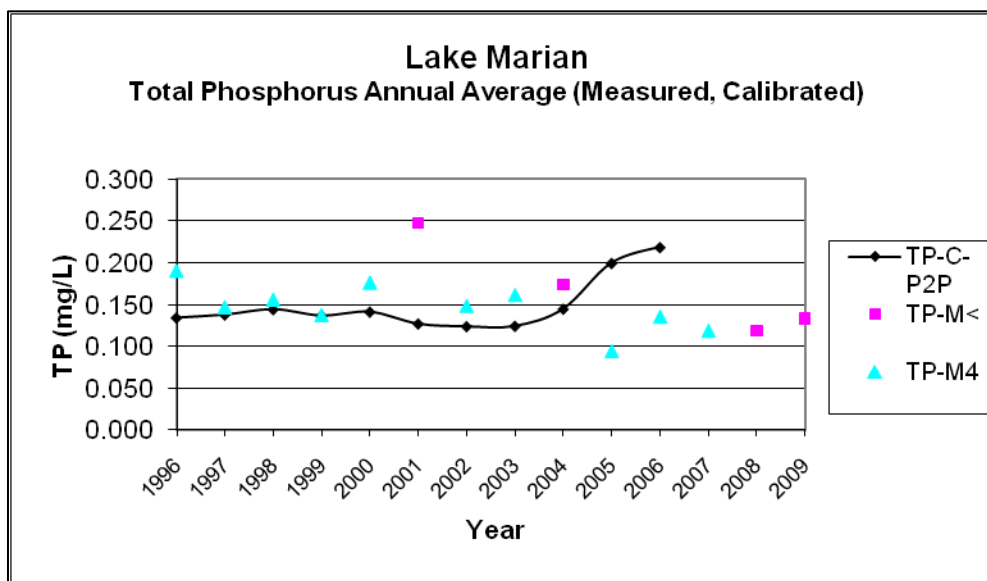


Figure 5.19 Lake Marian Total Phosphorus Means Comparison for Annual Average Measured Data and Calibration Results (1997 - 2000)

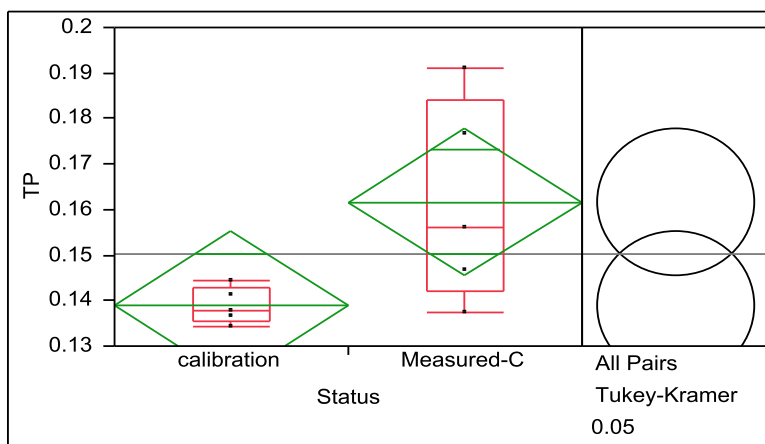


Table 5.13 Lake Marian Total Phosphorus Means Comparison for Annual Average Measured Data and Calibration Results (1997 - 2000)

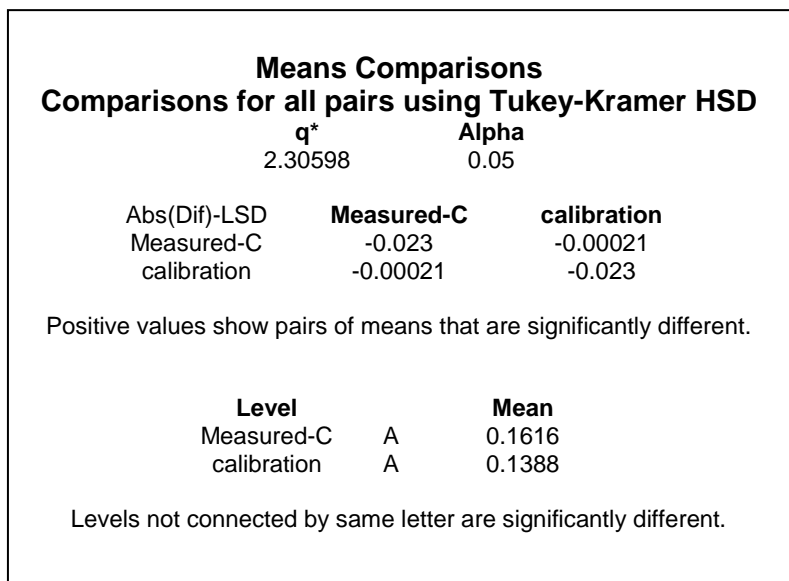


Figure 5.20 Lake Marian Total Phosphorus Means Comparison for Annual Average Measured Data and Validation Results (2001 - 2006)

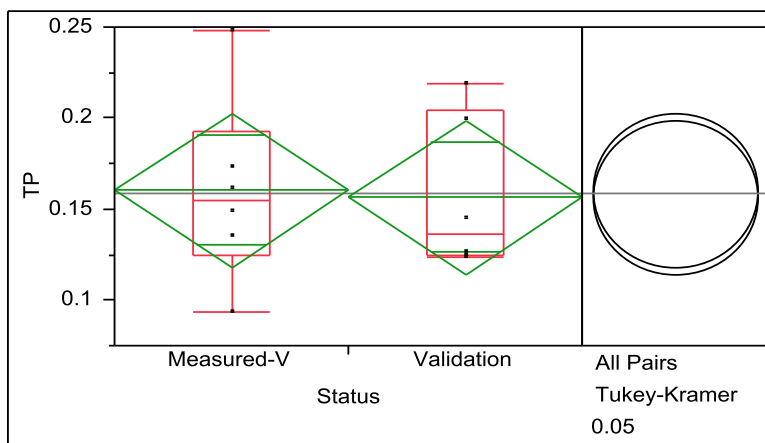


Table 5.14 Lake Marian Total Phosphorus Means Comparison for Annual Average Measured Data and Validation Results (2001 - 2006)

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
	q*	Alpha
	2.22813	0.05
Abs(Dif)-LSD		
Measured-V	-0.06016	-0.05624
Validation	-0.05624	-0.06016
Positive values show pairs of means that are significantly different.		
Level		Mean
Measured-V	A	0.1602
Validation	A	0.1563

The daily CChla calibration results are depicted on **Figure 5.21** and the annual means on **Figure 5.22**. The daily and annual average results indicate that the model is reproducing both the high and low CChla concentrations measured in the lake. **Figure 5.23** and **Table 5.15** comparing model annual average calibration predictions to the measured data (point to point) indicate the means are not significantly different at an alpha of 0.05. The annual average CChla validation results (**Figure 5.24** and **Table 5.16**) comparing model predictions to the measured data indicate the means are not significantly different at an alpha of 0.05. These results indicate that the model predictions of lake CChla are acceptable for predicting annual averages.

Figure 5.21 Lake Marian Chlorophyll a Daily Average Measured Data and Calibration/Validation Results (1996 - 2006)

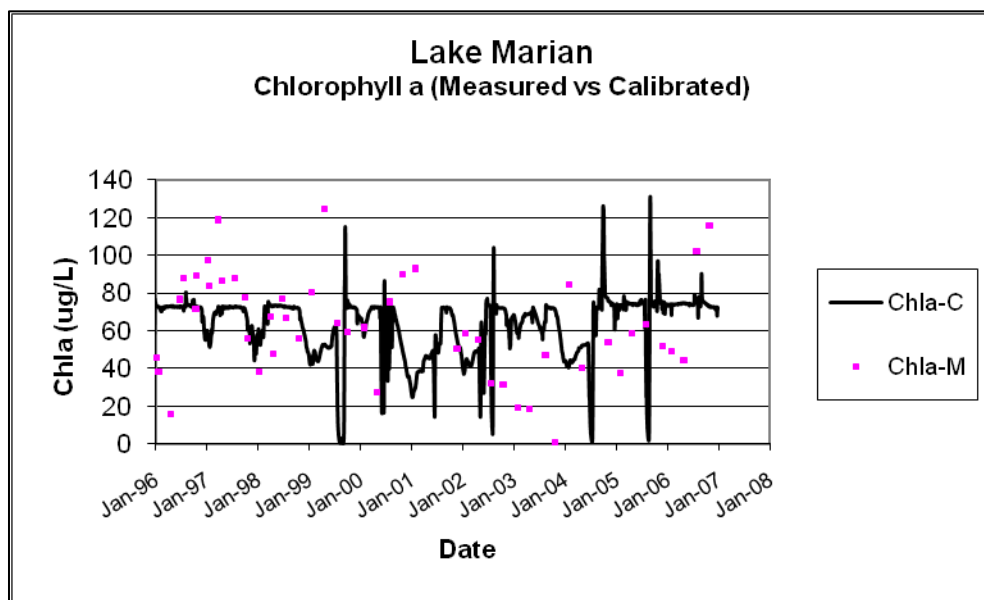


Figure 5.22 Lake Marian Chlorophyll a Annual Average Measured Data (1996 – 2009) and Calibration/Validation Results (1996 - 2006)

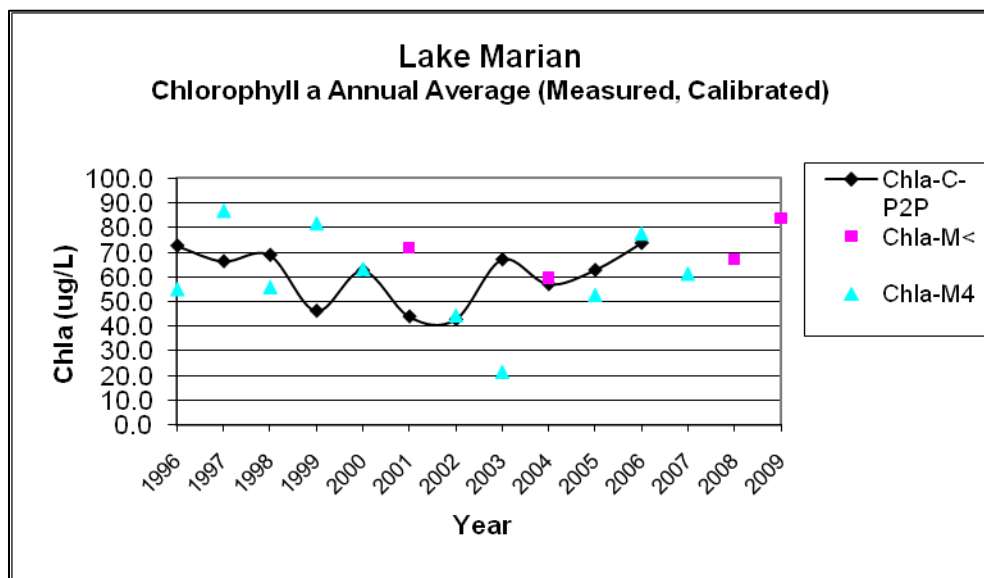


Figure 5.23 Lake Marian Chlorophyll a Means Comparison for Annual Average Measured Data and Calibration Results (1997 - 2000)

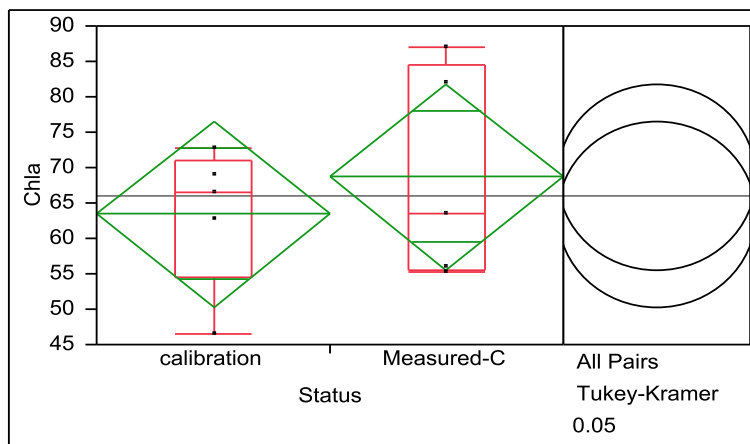


Table 5.15 Lake Marian Chlorophyll a Means Comparison for Annual Average Measured Data and Calibration Results (1997 - 2000)

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
	q*	Alpha
	2.30598	0.05
Abs(Dif)-LSD		
Measured-C	-18.5949	-13.3661
calibration	-13.3661	-18.5949
Positive values show pairs of means that are significantly different.		
Level		Mean
Measured-C	A	68.70
calibration	A	63.47
Levels not connected by same letter are significantly different.		

Figure 5.24 Lake Marian Chlorophyll a Means Comparison for Annual Average Measured Data and Validation Results (2001 - 2006)

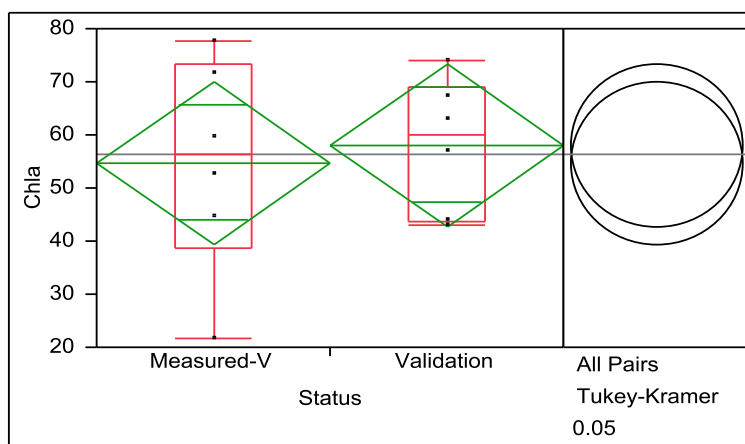


Table 5.16 Lake Marian Chlorophyll a Means Comparison for Annual Average Measured Data and Validation Results (2001 - 2006)

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
	q^*	Alpha
	2.22813	0.05
Abs(Dif)-LSD		
Validation	-21.6541	-18.3143
Measured-V	-18.3143	-21.6541
Positive values show pairs of means that are significantly different.		
Level		Mean
Validation	A	58.02
Measured-V	A	54.68
Levels not connected by same letter are significantly different.		

The annual TSI results are depicted on **Figure 5.25**. While the annual average results indicate that the model is underestimating the TSI in the lake, **Figure 5.26** and **Table 5.17** comparing model annual average calibration predictions to the measured data (point to point) indicate the means are not significantly different at an alpha of 0.05. The annual average TSI validation results (**Figure 5.27** and **Table 5.18**) comparing model predictions to the measured data indicate the means are not significantly different at an alpha of 0.05. These results indicate that the model predictions of lake TSI are acceptable for predicting annual averages.

Figure 5.25 Lake Marian TSI Annual Average Measured Data (1996 – 2009) and Calibration/Validation Results (1996 - 2006)

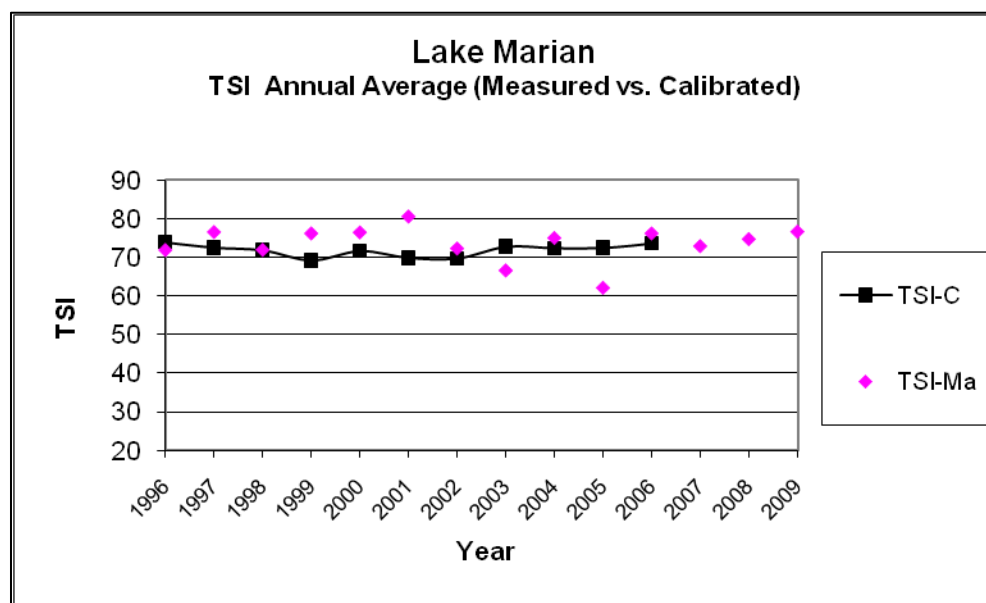


Figure 5.26 Lake Marian TSI Means Comparison for Annual Average Measured Data and Calibration Results (1997 - 2000)

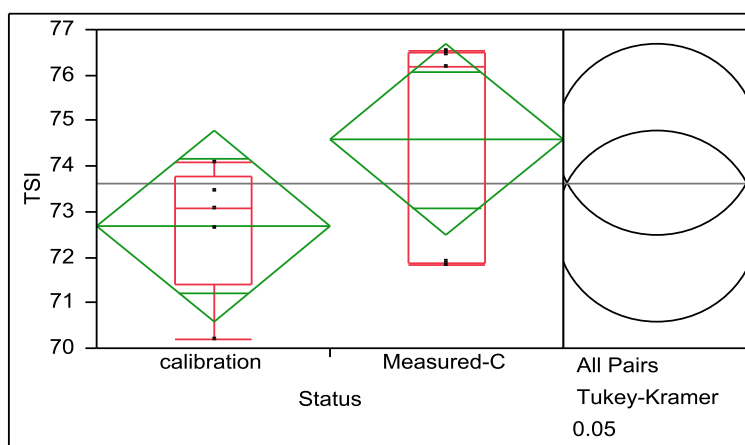


Table 5.17 Lake Marian TSI Means Comparison for Annual Average Measured Data and Calibration Results (1997 - 2000)

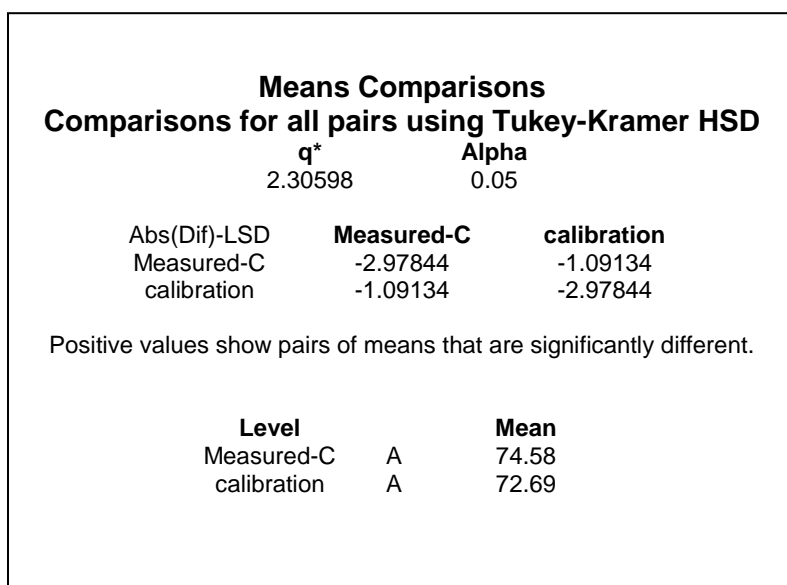


Figure 5.27 Lake Marian TSI Means Comparison for Annual Average Measured Data and Validation Results (2001 - 2006)

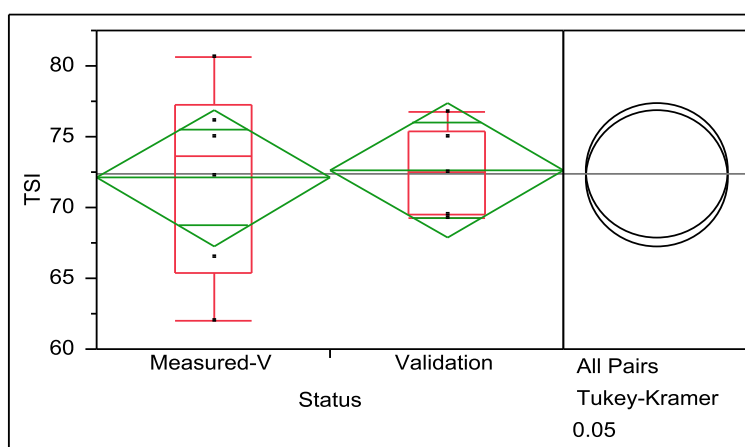


Table 5.18 Lake Marian TSI Means Comparison for Annual Average Measured Data and Validation Results (2001 - 2006)

Means Comparisons		
Comparisons for all pairs using Tukey-Kramer HSD		
	q*	Alpha
	2.22813	0.05
Abs(Dif)-LSD		
Validation	-6.74244	-6.23198
Measured-V	-6.23198	-6.74244
Positive values show pairs of means that are significantly different.		
	Level	Mean
Validation	A	72.58
Measured-V	A	72.07

The simulated annual mass balance for TP in Lake Marian is presented in **Table 5.19**. For each year, the table shows the sources of TP (positive values) to the water in the lake, and losses of TP from the lake water (negative values), along with the net change in TP mass in the lake water. Based on the results of the simulation summarized in **Table 5.19**, inflow from the basin (interflow plus runoff) accounts for 80.8% of the total TP load, baseflow accounts for 6.9%, sediment release 4.2%, and rainfall accounts for the remaining 8.1%. Overall, the model results show that about 75.3% of the TP load to the lake leaves the lake with the outflow, while 24.7% is removed through settling and transformation-uptake.

Table 5.19 HSPF Simulated Total Phosphorus Budget for Lake Marian from 1997 to 2006 in Pounds/Year

Year	Baseflow	Interflow	Runoff	Rainfall	Benthic release	Total Inflow	Settling	Outflow	Change
	TP lbs	TP lbs	TP lbs	TP lbs	TP lbs	TP lbs	TP lbs	TP lbs	TP lbs
1997	1074	7143	2050	1686	800	12753	-2991	-4036	5726
1998	1209	10554	3340	1451	812	17367	-3109	-9237	5022
1999	1355	8193	3930	1536	785	15799	-2246	-5096	8458
2000	282	1070	497	825	752	3426	-2522	-337	567
2001	949	4669	638	1274	709	8238	-2032	0	6206
2002	1477	10882	1886	1536	764	16545	-2418	-2518	11608
2003	1478	5762	1618	1477	804	11139	-2943	-5322	2875
2004	1726	13971	25147	1831	791	43466	-2583	-22633	18250
2005	2551	17179	20606	2268	826	43431	-3288	-29518	10624
2006	827	7381	5001	1222	787	15218	-3264	-4832	7123
AVG97-06	1293	8680	6471	1511	783	18738	-2740	-8353	7646
Percent	6.9	46.3	34.5	8.1	4.2	100	24.7	75.3	

¹ Inflows include surface runoff, baseflow, and interflow.

² Outflow to downstream basin (Lake Jackson).

The simulated annual mass balance for TN in Lake Marian is presented in **Table 5.20**. For each year, the table shows the sources of TN (positive values) to the water in the lake, and losses of TN from the lake water (negative values), along with the net change in TN mass in the lake water. Based on the results of the simulation and summarized values in the table, inflow from the basin (interflow plus runoff) accounts for 60.7% of the total TN load, inflow from baseflow accounts for 12.8%, sediment release 0.3%, and rainfall accounts for the remaining 26.2%. Overall, the model results show that about 45% of the TN load to the lake leaves the lake with the outflow, while 55% is removed through settling and transformation-uptake.

Table 5.20 HSPF Simulated Total Nitrogen Budget for Lake Marian from 1997 to 2006 in Pounds/Year

Year	Baseflow	Interflow	Runoff	Rainfall	Benthic release	Total Inflow	Settling	Outflow	Change
	TN lbs	TN lbs	TN lbs	TN lbs	TN lbs	TN lbs	TN lbs	TN lbs	TN lbs
1997	20472	54492	15341	56452	533	147291	111955	-45785	-22975
1998	23257	83705	25219	48592	541	181314	106819	-99174	-24678
1999	25895	63900	29781	51438	524	171538	-98148	-53371	20019
2000	5329	7789	3623	27626	501	44867	-98858	-3534	-57524
2001	18034	35472	4727	42641	473	101347	-87551	0	13796
2002	28275	84839	14203	51419	510	179246	-90707	-30033	58506
2003	28182	44900	12189	49448	536	135255	-97294	-64975	-27014
2004	33080	111989	191556	61282	528	398435	-97308	227415	73711
2005	49064	135822	156961	75938	551	418336	121958	284063	12315
2006	15816	57012	37913	40904	525	152170	132199	-45291	-25320
AVG97-06	24740	67992	49151	50574	522	192980	104280	85,364	2084
Percent	12.8	35.2	25.5	26.2	0.3	100.0	55	45	

¹ Inflows include surface runoff, baseflow, and interflow.

² Outflow is discharge to downstream basin (Lake Jackson).

5.3 Background Conditions

HSPF was used to describe and evaluate the “natural land use background condition” for the Lake Marian watershed. For this simulation, all current land uses were ‘reassigned’ to a mixture of Forest and Wetland. The current condition was maintained for all waterbody physical characteristics. From this point forward, the natural land use background will be referred to as “background.” As discussed earlier, for existing conditions, the threshold TSI value of 60 is exceeded in all of the ten years of simulation, and the lake is considered co-limited by nitrogen and phosphorus in all years except 2006, which was nitrogen-limited. Under the background

conditions, the lake is considered co-limited, and the threshold TSI value of 60 is exceeded in 7 of the 10 years simulated. Based on the background model run results in **Table 5.21**, the pre-developed lake should have had annual average TP concentrations ranging from 0.039 – 0.075 mg/L, with a long-term average of 0.050 mg/L. The pre-developed annual average TN concentrations ranged between 1.07 and 1.32 mg/L with a long-term average of 1.19 mg/L. The pre-developed annual average chlorophyll *a* ranged from 16.9 – 36.75 ug/L with an average of 24.7 ug/L. The resulting annual average TSI values ranged between 56.8 and 63.2, with a long-term average of 60.4. The background TSI of 60.4 was truncated to 60 for use in development of the TMDL target.

Table 5.21 Background Land Use Model Results

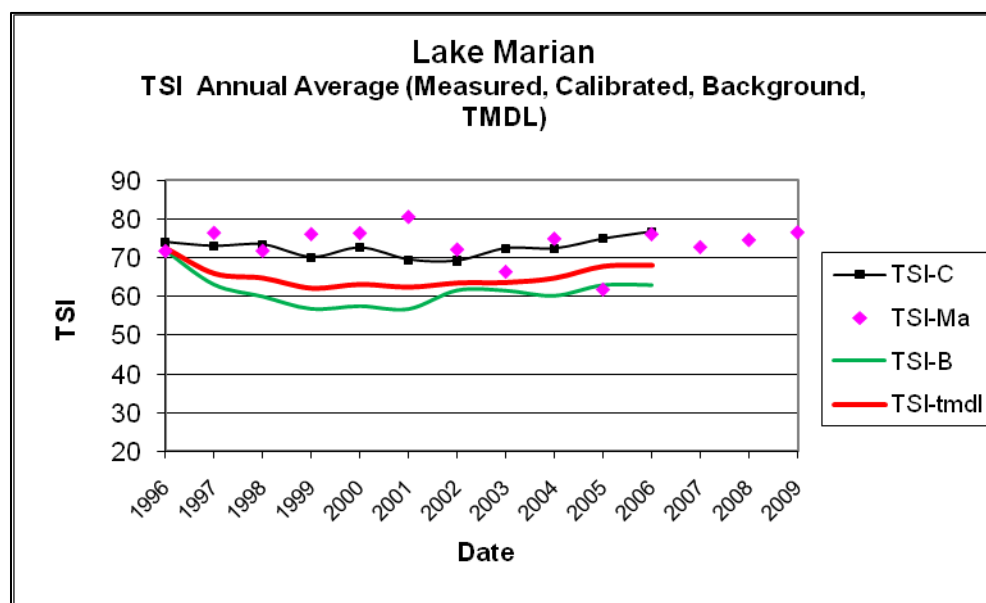
Year	TP (mg/l)	TN (mg/l)	Chl-a (ug/l)	TSI	TN/TP Ratio	Nutrient Limitation
1997	0.075	1.23	29.13	63.2	16.5	Co-limited
1998	0.054	1.09	25.29	60.1	20.2	Co-limited
1999	0.047	1.09	17.74	56.9	22.9	Co-limited
2000	0.046	1.16	18.95	57.6	24.9	Co-limited
2001	0.043	1.27	16.90	56.8	29.8	Co-limited
2002	0.040	1.32	20.42	61.6	33.0	P-limited
2003	0.039	1.28	20.95	61.6	32.9	P-limited
2004	0.044	1.29	26.34	60.2	29.3	Co-limited
2005	0.055	1.12	36.75	63.0	20.3	Co-limited
2006	0.060	1.07	36.12	63.0	17.7	Co-limited
Average	0.050	1.19	24.86	60.4	24.7	Co-limited

5.4 Selection of the TMDL Target

It should be recognized that the direct application of background as the restoration target TSI would not allow for any assimilative capacity. The IWR uses as one measure of impairment in lakes, a 10 unit change in TSI from “historical” levels. This 10 unit increase is assumed to represent the transition of a lake from one trophic state (say mesotrophic) to another nutrient enriched condition (eutrophic). The Department has assumed that allowing a 5 unit increase in TSI over the background condition would prevent a lake from becoming impaired (changing trophic states). Additionally, the TN/TP ratio of the current conditions in the impaired lake indicates co-limitation (mean ratio of 11.7 is trending towards to N-limitation) by both nitrogen and phosphorus in all years except 2006, which was N-limited. The TN/TP ratio for the background condition is strong co-limitation with a mean ratio of 24.7 and P-limitation in two

years (2002 and 2003). The final target developed for restoration of Lake Marian, included achieving a long-term average TSI of 65 (background of 60 plus 5) and co-limitation of TN and TP.

Figure 5.28 TSI For Measured Data, Calibrated Model, Background, and TMDL



The background model run was assessed for the years 1997 – 2006. An annual TSI was calculated for each year. The long-term (1997-2006) average TSI was determined by using the long-term average TN, TP, and Chlorophyll *a* to calculate a TSI of 60.4 (rounded to 60). As has been Department's practice, when acceptable background conditions can be established, the target for TMDL development becomes the background TSI plus 5 TSI units as shown on **Figure 5.28**. This establishes the long-term average target TSI for Lake Marian as 65 (60 + 5 TSI units).

Once the target TSI of 65 was established, HSPF was rerun for existing conditions with decreasing loads for runoff, interflow, and sediment nutrient flux (loads from baseflow and direct rainfall on lake were not reduced) until both the long-term average target TSI was met and co-limitation (trending towards P-limitation) was achieved. The long-term average (1997 – 2006) results for TN, TP, and CChla from each series of reductions were compared to the TSI target, nutrient limitations, and background concentrations to ensure that the load reduction did not result in average water quality better than the background conditions.

Percent reductions in watershed loading for current conditions were applied to runoff, interflow, and internal flux (based on a proportional reduction to the watershed load). No reductions were applied to baseflow or direct rainfall onto the lake (**Table 5.22**).

The 1997 – 2006 average TP existing loading from all sources of 18,738 lbs/yr is shown in **Tables 5.19** and **5.22**. The total existing watershed load of 16,444 lbs/yr is obtained by subtracting the loads from rainfall on the lake (1,511 lbs/yr) and benthic release (783 lbs/yr) from the total from all sources. The TP TMDL (watershed) in **Table 5.22** depicts the resulting total allowable watershed load of 5,838 lbs/yr (without rainfall on lake or benthic release). The

resulting percent reduction of 65% applied to the existing watershed load will be applied to both the load allocation (LA) and stormwater Wasteload Allocation (MS4) components of the TMDL.

The 1997 – 2006 average TN existing loading from all sources of 192,980 lbs/yr is shown in **Tables 5.20** and **5.22**. The total existing watershed load of 141,884 lbs/yr is obtained by subtracting the loads from rainfall on the lake (50,574 lbs/yr) and benthic release (522 lbs/yr) from the total from all sources. **Table 5.22** depicts the resulting total allowable watershed load of 71,597 lbs/yr (without rainfall on lake or benthic release). The resulting percent reduction of 50% applied to the existing watershed load will be applied to both the load allocation (LA) and stormwater Wasteload Allocation (MS4) components of the TMDL.

As the TMDL is based on the percent reduction in total watershed loading and any natural landuses are held harmless, the percent reductions for the anthropogenic sources may be greater than those proposed.

The goal of the TMDL is to achieve and maintain an average lake TSI of no greater than 65, with strong co-limitation. Combinations of CChla, TN, and TP concentrations in the lake other than those derived from the model results (CChla of 35.3 ug/L, TN of 1.50 mg/L, and TP of 0.067 mg/L) could still result in a TSI of 65 and successful restoration of the lake. The modeled in-lake concentrations (based on watershed loadings and model in-lake processes) have resulted in just one possible combination. Maintaining the long-term annual average watershed loadings for TP and TN established in this TMDL should result in attaining the TMDL target TSI of 65 and strong co-limitation in the lake.

Table 5.22 Existing and TMDL TN and TP Loads and Percent Reductions

Condition	Year	Baseflow (lbs/yr)	Interflow (lbs/yr)	Runoff (lbs/yr)	Rainfall (lbs/yr)	Benthic Release (lbs/yr)	Total Inflow (lbs/yr) (1)
TP-Existing Total	AVG 97-06	1,293	8,680	6,471	1,511	783	18,738
TP-Existing Watershed	AVG 97-06	1,293	8,680	6,471			16,444
TP-TMDL Total	AVG 97-06	1,293	2,604	1,941	1,511	235	7,349
TP-TMDL watershed	AVG 97-06	1,293	2,604	1,941			5,838
TP TMDL %Reduction	AVG 97-06						65%
TN-Existing Total	AVG 97-06	24,740	67,992	49,151	50,574	522	192,980
TN-Existing Watershed	AVG 97-06	24,740	67,992	49,151			141,883
TN-TMDL Total	AVG 97-06	24,740	27,197	19,660	50,574	209	122,171
TN-TMDL Watershed	AVG 97-06	24,740	27,197	19,660			71,597
TN TMDL %Reduction	AVG 97-06						50%

(1) TMDL based on watershed loadings. Watershed load does not include load from the benthic flux or rainfall directly on the lake. The loads were rounded to a whole number. Percent reductions rounded up.

5.5 Critical Conditions

The estimated assimilative capacity was based on annual average conditions (i.e., values from all four seasons in each calendar year) rather than critical/seasonal conditions because (a) the methodology used to determine the assimilative capacity does not lend itself very well to short-term assessments, (b) the Department is generally more concerned with the net change in overall primary productivity in the segment, which is better addressed on an annual basis, and (c) the methodology used to determine impairment in lakes is based on an annual average and requires data from all four quarters of a calendar year.

Chapter 6: DETERMINATION OF THE TMDL

6.1 Expression and Allocation of the TMDL

A TMDL can be expressed as the sum of all point source loads (wasteload allocations or WLAs), nonpoint source loads (load allocations or LAs), and an appropriate margin of safety (MOS) that takes into account any uncertainty about the relationship between effluent limitations and water quality:

As mentioned previously, the WLA is broken out into separate subcategories for wastewater discharges and stormwater discharges regulated under the NPDES Program:

$$\text{TMDL} \cong \sum \text{WLAs}_{\text{wastewater}} + \sum \text{WLAs}_{\text{NPDES Stormwater}} + \sum \text{LAs} + \text{MOS}$$

It should be noted that the various components of the TMDL equation may not sum up to the value of the TMDL because a) the WLA for NPDES stormwater is typically based on the percent reduction needed for nonpoint sources and is accounted for within the LA, and b) TMDL components can be expressed in different terms [for example, the WLA for stormwater is typically expressed as a percent reduction and the WLA for wastewater is typically expressed as a mass per day].

WLAs for stormwater discharges are typically expressed as “percent reduction” because it is very difficult to quantify the loads from MS4s (given the numerous discharge points) and to distinguish loads from MS4s from other nonpoint sources (given the nature of stormwater transport). The permitting of stormwater discharges is also different than the permitting of most wastewater point sources. Because stormwater discharges cannot be centrally collected, monitored and treated, they are not subject to the same types of effluent limitations as wastewater facilities, and instead are required to meet a performance standard of providing treatment to the “maximum extent practical” through the implementation of Best Management Practices.

This approach is consistent with federal regulations [40 CFR § 130.2(I)], which state that TMDLs can be expressed in terms of mass per time (e.g. pounds per day), toxicity, or **other appropriate measure**. The NPDES Stormwater WLA and Load Allocation (LA) are expressed as a percent reduction in the stormwater from these areas. The TMDL for Lake Marian is expressed in terms of pounds per year and represents the long-term annual average load of TN and TP from all watershed sources that the waterbody can assimilate and maintain the Class III narrative nutrient criterion (**Table 6.1**).

Table 6.1 Lake Marian TMDL Load Allocations

WBID	Parameter	WLA		LA (lbs/year)	MOS	TMDL (lbs/year) (A)
		Wastewater (lbs/year)	Stormwater (% reduction)			
3184	TN	NA	50	50	Implicit	71,597
3184	TP	NA	65	65	Implicit	5,838

(A) Allowable load from all watershed sources

The TMDL daily watershed load for TN is 196.2 lbs/day and TP equals 15.9 lbs/day.

These reductions resulted in long-term average lake concentrations of 0.067 mg/L for TP, 1.50 mg/L for TN, and 35.3 ug/L for chlorophyll *a* with an average TN/TP ratio of 22.3.

6.2 Load Allocation (LA)

Because the exact boundaries between those areas of the watershed covered by the WLA allocation for stormwater and the LA allocation are not known, both the LA and the WLA for stormwater will receive the same percent reduction. The LA is a 65% reduction in TP and a 50% reduction in TN of the total nonpoint source watershed loadings from the period 1997 - 2006. As the TMDL is based on the percent reduction in total watershed loading and any natural landuses are held harmless, the percent reductions for the anthropogenic sources may be greater. It should be noted that the LA may include loading from stormwater discharges regulated by the Department and the Water Management District that are not part of the NPDES Stormwater Program (see Appendix A).

6.3 Wasteload Allocation (WLA)

NPDES Wastewater Discharges

As noted in Chapter 4, Section 4.2.1, there are no active National Pollutant Discharge Elimination System (NPDES) permitted facilities located within the Lake Marian watershed that discharge surface water within the watershed. Therefore, the WLA_{wastewater} for the Lake Marian TMDL is not applicable because there are no wastewater or industrial wastewater NPDES facilities that discharge directly to Lake Marian.

NPDES Stormwater Discharges

The stormwater collection systems in the Lake Marian watershed, which are owned and operated by Osceola County, are covered by NPDES Phase II MS4 permit number FLR04E012. The collection system for the Florida Department of Transportation District 5 is covered by NPDES permit number FLR04E024. The collections systems for the Florida Turnpike are covered by NPDES permit number FLR04E049. The wasteload allocation for stormwater discharges is a 65% reduction in TP and a 50% reduction in TN of the total watershed loading from the period 1997-2006, which are the required percent reductions in stormwater nonpoint sources. It should be noted that any MS4 permittee will only be responsible for reducing the anthropogenic loads associated with stormwater outfalls for which it owns or otherwise has responsible control, and is not responsible for reducing other nonpoint source loads within its jurisdiction. As the TMDL is based on the percent reduction in total watershed loading and any

natural landuses are held harmless, the percent reduction for just the anthropogenic sources may be greater.

6.4 Margin of Safety (MOS)

TMDLs must address uncertainty issues by incorporating a MOS into the analysis. The MOS is a required component of a TMDL and accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving waterbody [Clean Water Act, Section 303(d)(1)(c)]. Considerable uncertainty is usually inherent in estimating nutrient loading from nonpoint sources, as well as predicting water quality response. The effectiveness of management activities (e.g., stormwater management plans) in reducing loading is also subject to uncertainty.

The MOS can either be implicitly accounted for by choosing conservative assumptions about loading or water quality response, or explicitly accounted for during the allocation of loadings. Consistent with the recommendations of the Allocation Technical Advisory Committee (Florida Department of Environmental Protection, February 2001), an implicit margin of safety (MOS) was used in the development of the Lake Marian TMDL. An implicit MOS was used because the TMDL was based on the conservative decisions associated with a number of the modeling for Lake Marian.

Chapter 7: NEXT STEPS: IMPLEMENTATION PLAN DEVELOPMENT AND BEYOND

7 TMDL Implementation

Following the adoption of this TMDL by rule, the Department will determine the best course of action regarding its implementation. Depending upon the pollutant(s) causing the waterbody impairment and the significance of the waterbody, the Department will select the best course of action leading to the development of a plan to restore the waterbody. Often this will be accomplished cooperatively with stakeholders by creating a Basin Management Action Plan, referred to as the BMAP. Basin Management Action Plans are the primary mechanism through which TMDLs are implemented in Florida [see Subsection 403.067(7) F.S.]. A single BMAP may provide the conceptual plan for the restoration of one or many impaired waterbodies.

If the Department determines that a BMAP is needed to support the implementation of this TMDL, a BMAP will be developed through a transparent stakeholder-driven process intended to result in a plan that is cost-effective, technically feasible, and meets the restoration needs of the applicable waterbodies. Once adopted by order of the Department Secretary, BMAPs are enforceable through wastewater and municipal stormwater permits for point sources and through BMP implementation for nonpoint sources. Among other components, BMAPs typically include:

- Water quality goals (based directly on the TMDL);
- Refined source identification;
- Load reduction requirements for stakeholders (quantitative detailed allocations, if technically feasible);
- A description of the load reduction activities to be undertaken, including structural projects, nonstructural BMPs, and public education and outreach;
- A description of further research, data collection, or source identification needed in order to achieve the TMDL;
- Timetables for implementation;
- Implementation funding mechanisms;
- An evaluation of future increases in pollutant loading due to population growth;
- Implementation milestones, project tracking, water quality monitoring, and adaptive management procedures; and
- Stakeholder statements of commitment (typically a local government resolution).

BMAPs are updated through annual meetings and may be officially revised every five years. Completed BMAPs in the state have improved communication and cooperation among local stakeholders and state agencies, improved internal communication within local governments, applied high-quality science and local information in managing water resources, clarified obligations of wastewater point source, MS4 and non-MS4 stakeholders in TMDL

implementation, enhanced transparency in DEP decision-making, and built strong relationships between DEP and local stakeholders that have benefited other program areas.

However, in some basins, and for some parameters, particularly those with fecal coliform impairments, the development of a BMAP using the process described above will not be the most efficient way to restore a waterbody, such that it meets its designated uses. Why? Because fecal coliform impairments result from the cumulative effects of a multitude of potential sources, both natural and anthropogenic. Addressing these problems requires good old fashioned detective work that is best done by those in the area. There are a multitude of assessment tools that are available to assist local governments and interested stakeholders in this detective work. The tools range from the simple – such as Walk the WBIDs and GIS mapping - to the complex such as Bacteria Source Tracking. Department staff will provide technical assistance, guidance, and oversight of local efforts to identify and minimize fecal coliform sources of pollution.

References

- Bicknell, B. R., Imhoff, J. C., Kittle, J. L., Donigan, A. S., Jr. and Johanson, R. C. 2001. *Hydrologic Simulation Program-Fortran, User's manual for Release 12*. U.S. Environmental Protection Agency, EPA/600/R-97/080, Environmental Research Laboratory, Athens, GA.
- Carlson, Robert E. 1977. *A Trophic State Index for Lakes*. Limnology and Oceanography. 22: 361-369.
- CDM, 2002. *Northern Coastal Basin Watersheds Hydrology Model Development: Pellicer Creek Planning Unit 9B*. Prepared for the St. Johns River Water Management District, Palatka, FL.
- CDM 2003. *Framework Model of the Upper St. Johns River Basin: Hydrology and Hydraulics, October 2003*. Prepared for the St. Johns River Water Management District, Palatka, FL.
- CDM, 2008. *Kissimmee River Watershed TMDL Model Development Report Volumes 1 and 2*. Prepared for the Florida Department of Environmental Protection
- Florida Department of Environmental Protection, February 2001. *A Report to the Governor and the Legislature on the Allocation of Total Maximum Daily Loads in Florida*. Florida Department of Environmental Protection, Allocation Technical Advisory Committee, Division of Water Resource Management, Bureau of Watershed Management, Tallahassee, Florida.
- , April 2001. Chapter 62-302, *Surface Water Quality Standards*, Florida Administrative Code (F.A.C.), Florida Department of Environmental Protection, Division of Water Resource Management, Bureau of Watershed Management, Tallahassee, Florida.
- , April 2001. *Chapter 62-303, Identification of Impaired Surface Waters Rule (IWR)*, Florida Administrative Code. Florida Department of Environmental Protection, Division of Water Resource Management, Bureau of Watershed Management, Tallahassee, Florida.
- , June 2004. Division of Water Resource Management, Bureau of Information Systems, Geographic Information Systems Section, Florida Department of Environmental Protection, Tallahassee, Florida. Available at <http://www.dep.state.fl.us/gis/contact.htm>
- Florida Department of Health. Florida Department of Health web site. Available at <http://www.doh.state.fl.us/>; or <http://www.doh.state.fl.us/environment/OSTDS/statistics/ostdsstatistics.htm>.
- Florida Department of Transportation, 1999. *Florida Land Use, Cover and Forms Classification System (FLUCCS)*. Florida Department of Transportation Thematic Mapping Section.
- FWRA, 1999. *Florida Watershed Restoration Act*, Chapter 99-223, Laws of Florida.
- Hartigan, J.P., T.F. Quasebarth and E. Southerland, 1983 (A). *Calibration of NPS Loading Factors*. ASCE Journal of Environmental Engineering, Vol. 109, No. 6.

Hartigan, J.P., J.A. Friedman and E. Southerland, 1983 (B). *Post-Audit of Lake Model Used for NPS Management*. ASCE Journal of Environmental Engineering, Vol. 109, No. 6.

National Weather Service, 2004. National Weather Service, National Climatic Data Center, Climate Interactive Rapid Retrieval User System (CIRRUS) Database hosted by the Southeast Regional Climate Center web site. Available at <http://www.dnr.state.sc.us/pls/cirrus/cirrus.login>.

NVPDC, 1983 (primary author J.P. Hartigan). *Chesapeake Bay Basin Model Final Report*. Prepared for the U.S. Environmental Protection Agency Chesapeake Bay Program, Annapolis, MD.

NVPDC, 1986 (primary author R.A. Wagner). *Reverification of Occoquan Basin Computer Model: Post-Audit No. 2 with 1982-1984 Monitoring Data*. Prepared for the Occoquan Basin Nonpoint Pollution Management Program.

Over, T.M., Murphy, E.A., Ortel, T.W., and Ishii, A.L., 2007, *Comparison between*

SFWMD, 2001. *Upper Kissimmee Chain of Lakes Routing Model, Appendix B* (PBSJ, XPSofWare, and SFWMD, 2001

URS Greiner, 1998. *Basin Planning for Boggy Creek and Lake Hart Watersheds, Final Report*. Prepared for Stormwater Management Department, Public Works Division, Board of County Commissioners, Orange County, FL.

URS 2006, *Model ID & Acquisition TM for the Florida Department of Environmental Protection and Center for Environmental Studies Florida Atlantic University*.

U. S. Census Bureau Web Site. 2008. Available at <http://www.census.gov/>; or http://factfinder.census.gov/servlet/GCTTable?_bm=y&-geo_id=04000US12&-box_head_nbr=GCT-PH1&-ds_name=DEC_2000_SF1_U&-lang=en&-format=ST-2&-sse=on.

U. S. Environmental Protection Agency, April 1991. *Guidance for Water Quality – Based Decisions: The TMDL Process*. U. S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA-440/4-91-001.

—, November 1999. *Protocol for Developing Nutrient TMDLs*. U. S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA841-B-99-007.

—, 2000. *EPA BASINS Technical Note 6: Estimating Hydrology and Hydraulic Parameters for HSPF*.

—, 2001. *Better Assessment Science Integrating Point & Non-point Sources BASINS version 3.0 User Manual*, Electronic File, <http://www.epa.gov/waterscience/basins/bsnsdocs.html>, Accessed June 2007.

—, July 2003. *40 CFR 130.2(l)*, Title 40 – Protection of the Environment, Chapter I – U.S. Environmental Protection Agency, Part 130 – Water Quality Planning and Management, U.S. Environmental Protection Agency, Washington, D.C.

USGS, 2002. *Simulation of Runoff and Water Quality for 1990 and 2008 Land-Use Conditions in the Reedy Creek Watershed, East-Central Florida*. Prepared in cooperation with the Reedy Creek Improvement District.

Appendices

Appendix A: Background Information on Federal and State Stormwater Programs

In 1982, Florida became the first state in the country to implement statewide regulations to address the issue of nonpoint source pollution by requiring new development and redevelopment to treat stormwater before it is discharged. The Stormwater Rule, as authorized in Chapter 403, F.S., was established as a technology-based program that relies on the implementation of BMPs that are designed to achieve a specific level of treatment (i.e., performance standards) as set forth in Chapter 62-40, F.A.C.

The rule requires the state's water management districts (WMDs) to establish stormwater pollutant load reduction goals (PLRGs) and adopt them as part of a SWIM plan, other watershed plan, or rule. Stormwater PLRGs are a major component of the load allocation part of a TMDL. To date, stormwater PLRGs have been established for Tampa Bay, Lake Thonotosassa, the Winter Haven Chain of Lakes, the Everglades, Lake Okeechobee, and Lake Apopka. To date, no PLRG has been developed for Lake Marian.

In 1987, the U.S. Congress established Section 402(p) as part of the federal Clean Water Act Reauthorization. This section of the law amended the scope of the federal NPDES permitting program to designate certain stormwater discharges as "point sources" of pollution. The EPA promulgated regulations and began implementation of the Phase I NPDES stormwater program in 1990. These stormwater discharges include certain discharges that are associated with industrial activities designated by specific Standard Industrial Classification (SIC) codes, construction sites disturbing five or more acres of land, and master drainage systems of local governments with a population above 100,000, which are better known as municipal separate storm sewer systems (MS4s). However, because the master drainage systems of most local governments in Florida are interconnected, the EPA implemented Phase I of the MS4 permitting program on a countywide basis, which brought in all cities (incorporated areas), Chapter 298 urban water control districts, and the Florida Department of Transportation throughout the fifteen counties meeting the population criteria. The Department received authorization to implement the NPDES stormwater program in 2000.

An important difference between the NPDES and other state stormwater permitting programs is that the NPDES program covers both new and existing discharges, while the other state programs focus on new discharges. Additionally, Phase II of the NPDES Program, implemented in 2003, expands the need for these permits to construction sites between one and five acres, and to local governments with as few as 1,000 people. While these urban stormwater discharges are now technically referred to as "point sources" for the purpose of regulation, they are still diffuse sources of pollution that cannot be easily collected and treated by a central treatment facility similar to other point sources of pollution, such as domestic and industrial wastewater discharges. It should be noted that all MS4 permits issued in Florida include a re-opener clause that allows permit revisions to implement TMDLs when the implementation plan is formally adopted.

Appendix B: Electronic Copies of Measured Data and CDM, 2008 Report for Lake Marian TMDL

All information gathered by CDM and the HSPF model setup, calibration/validation, is contained within a Report titled "Kissimmee River Watershed TMDL Model Development Report January 2008" (CDM, 2008) and is available upon request (~100 megabytes on disk). Lake Marian is included in the HSPF model project termed UKL_Open.UCI.

The CDM, 2008 report and all data used in the Lake Marian TMDL report is available upon request. Please contact the individual listed below to obtain this information.

Douglas Gilbert, Environmental Manager
Florida Department of Environmental Protection
Bureau of Watershed Restoration
Watershed Evaluation and TMDL Section
2600 Blair Stone Road, Mail Station 3555
Tallahassee, FL 32399-2400
douglas.gilbert@dep.state.fl.us
Phone: (850) 245-8450;
Fax: (850) 245-8536

Appendix C: HSPF Water Quality Calibration Values for Lake Marian

HSPF Variable	Lake Marian
Water Temperature	
CFSAEX	0.50
KATRAD	9.37
KCOND	6.12
KEVAP	2.24
Total Suspended Solids	
KSAND	6
EXPSND	1.5
W	1.0E-05
TAUCD	0.02
TAUCS	0.32
M	1.2
W	1.6E-06
TAUCD	0.02
TAUCS	0.46
M	1.2

Dissolved Oxygen and Oxygen Demand	
KBOD20	0.0012
TCBOD	1.037
KODSET	0
BENOD	8.4
TCBEN	1.037
REAKT (2)	---
REAKT (3)	---
EXPRED	---
EXPREV	---
TCGINV	1.047

NUTRX Module	
KTAM20	0.003
TCNIT	1.07

PLANK Module	
RATCLP	3.0
NONREF	0.85
ALNPR	0.8
EXTB	0.23
MALGR	0.108
CMMLT	0.033
CMMN	0.045
CMMNP	0.028
CMMP	0.015
TALGRH	95
TALGRL	43
TALGRM	85
ALR20	0.003
ALDH	0.008
ALDL	0.002
CLALDH	75
PHYSET	0.0008
REFSET	0.0005
CVBO	1.31
CVBPC	106
CVBPN	10
BPCNTC	49

Appendix D: Raw Data for Lake Marian

Remark Codes

+ is where TN was calculated from component parts (NO₂+3 + ammonia + organic)

& For CChla result reported was less than detection limit of 1.0 ug/L and assigned a value of 1.0 ug/L

A Value is arithmetic mean of two or more determinations.

I Value is between the method detection limit and practical quantitation limit

J Value is estimated

Q sample held beyond holding time

T Value is less than the method detection limit for information only

U Compound not detected.

Alkalinity

Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
ALK	112WRD 02268800	5/24/1966			10.0			
ALK	112WRD 02268800	8/9/1966			13.0			
ALK	112WRD 02268800	5/8/1967			14.0			
ALK	112WRD 02268800	4/18/1968	1645		19.0			
ALK	112WRD 02268800	4/2/1970	1230		15.0			
ALK	112WRD 02268800	8/31/1970	1130		17.0			
ALK	112WRD 02268800	9/2/1971	1330		16.0			
ALK	112WRD 02268800	4/19/1972	1045		25.0			
ALK	112WRD 02268800	10/4/1972	1215		23.0			
ALK	112WRD 02268800	4/25/1973	1000		21.0			
ALK	112WRD 02268800	10/30/1973	1125		16.0			
ALK	112WRD 02268800	4/29/1974	1255		22.0			
ALK	112WRD 02268800	10/15/1974	1005		20.0			
ALK	112WRD 02268800	5/28/1975	1000		27.0			
ALK	112WRD 02268800	9/15/1975	925		18.0			
ALK	112WRD 02268800	4/20/1976	1445		16.0			
ALK	112WRD 02268800	5/17/1977	1130		24.0			
ALK	112WRD 02268800	5/23/1978	1030		31.0			
ALK	112WRD 02268800	5/30/1979	1500		24.0			
ALK	112WRD 02268800	4/30/1980	1430		30.0			
ALK	112WRD 02268800	4/29/1981	1115		28.0			
ALK	21FLA 26010952	1/15/1985	844	6	27.0			
ALK	21FLA 26010952	9/24/1985	830	7	25.0			
ALK	21FLA 26010952	11/10/1987	815	8	24.0			
ALK	21FLA 26010952	2/16/1988	835	7	21.5			
ALK	21FLA 26010952	5/24/1988	905	2	22.7			
ALK	21FLA 26010952	7/18/1988	815	2	24.8			
ALK	21FLSFWMFDEP02	9/22/1993	850	0.5	33.3			
ALK	21FLSFWMFDEP01	9/22/1993	940	0.5	33.5			
ALK	21FLA 26010952	10/11/1993	855	6.56	36.4			
ALK	21FLA 26010952	1/24/1994	845	6.56	35.9			

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
ALK	21FLA 26010952	4/11/1994	915	6.56	41.1			
ALK	21FLA 26010952	7/18/1994	1513	6.56	36.0			
ALK	21FLSFWMFDEP01	10/4/1994	1700	0.5	30.3			
ALK	21FLSFWMFDEP01	10/4/1994	1700	1.64	30.3			
ALK	21FLSFWMFDEP02	10/4/1994	1715	0.5	29.8			
ALK	21FLSFWMFDEP02	10/4/1994	1715	1.64	29.8			
ALK	21FLA 26010952	10/24/1994	933	6.56	30.2			
ALK	21FLA 26010952	1/30/1995	1330	6.56	25.2			
ALK	21FLA 26010952	4/10/1995	925	6.56	24.2			
ALK	21FLA 26010952	8/14/1995	1452	7.87	23.7			
ALK	21FLA 26010952	10/16/1995	1305	7.87	20.8			
ALK	21FLA 26010952	1/22/1996	1335	7.71	20.7			
ALK	21FLGFWFGFCCR0590	2/5/1996	1545	0	24.0	D		
ALK	21FLGFWF03090101-LM-01	2/5/1996	1545	0	24.0			
ALK	21FLA 26010952	4/1/1996	1434	7.54	21.0			
ALK	21FLGFWFGFCCR0590	5/6/1996	1505	0	35.0	D		
ALK	21FLGFWF03090101-LM-01	5/6/1996	1505	0	35.0			
ALK	21FLA 26010952	7/8/1996	852	7.54	22.6			
ALK	21FLA 26010952	7/8/1996	857	7.54	22.6			
ALK	21FLGFWF03090101-LM-01	8/5/1996	1615	0	38.0			
ALK	21FLA 26010952	10/28/1996	945	7.22	22.3			
ALK	21FLGFWF03090101-LM-01	11/4/1996	1520	0	25.0			
ALK	21FLA 26010952	1/21/1997	950	6.56	24.1			
ALK	21FLGFWF03090101-LM-01	2/3/1997	1525	0	30.0			
ALK	21FLA 26010952	4/7/1997	1018	6.72	25.8			
ALK	21FLA 26010952	4/7/1997	1023	6.89	25.8			
ALK	21FLGFWF03090101-LM-01	5/5/1997		0	23.0			
ALK	21FLA 26010952	8/4/1997	1345	5.25	26.0			
ALK	21FLGFWF03090101-LM-01	8/4/1997	1752	0	25.0			
ALK	21FLA 26010952	10/13/1997	1015	7.54	24.2			
ALK	21FLGFWF03090101-LM-01	11/3/1997	1615	0	35.0			
ALK	21FLA 26010952	1/20/1998	1035	7.87	15.2	A		
ALK	21FLA 26010952	4/13/1998	955	7.54	14.8			
ALK	21FLGFWF03090101-LM-01	5/4/1998		0	16.0			

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
ALK	21FLA 26010952	7/6/1998	948	8.2	18.8			
ALK	21FLGFWF03090101-LM-01	8/3/1998		0	21.0			
ALK	21FLGFWF03090101-LM-01	11/2/1998	1545	0	81.0			
ALK	21FLGFWF03090101-LM-01	2/1/1999	1130	0	35.0			
ALK	21FLGFWF03090101-LM-01	5/3/1999	1320	0	37.0			
ALK	21FLGFWF03090101-LM-01	8/2/1999	1410	0	31.0			
ALK	21FLCEN 26011014	9/27/1999	0	0.3	17.0			
ALK	21FLCEN 26011012	9/27/1999	0	0.3	20.0			
ALK	21FLCEN 26011013	9/27/1999	0	0.3	17.5			
ALK	21FLGFWF03090101-LM-01	10/15/1999	1059	0	34.0			
ALK	21FLGFWF03090101-LM-01	2/7/2000	1231	0	30.0			
ALK	21FLGFWF03090101-LM-01	5/15/2000	930	0	18.0			
ALK	21FLGFWF03090101-LM-01	8/14/2000	900	0	38.0			
ALK	21FLGFWF03090101-LM-01	11/13/2000	1000	0	32.0			
ALK	21FLGFWF03090101-LM-01	2/12/2001	830	0	2.2			
ALK	21FLGFWF03090101-LM-01	12/3/2001		0	26.0			
ALK	21FLGFWF03090101-LM-01	5/6/2002	1015	0.5	36.0			
ALK	21FLGFWF03090101-LM-01	8/5/2002	815	0	31.0			
ALK	21FLGFWF03090101-LM-01	10/28/2002	900	0.5	32.0			
ALK	21FLGFWF03090101-LM-01	2/10/2003	700	0.5	30.0			
ALK	21FLGFWF03090101-LM-01	5/5/2003	1000	0.5	27.0			
ALK	21FLGFWF03090101-LM-01	11/3/2003	930	0.5	28.0			
ALK	21FLGFWF03090101-LM-01	2/9/2004	1500	0.5	28.0			
ALK	21FLGFWF03090101-LM-01	5/10/2004	0	0.1	23.0			
ALK	21FLGFWF03090101-LM-01	11/15/2004	1410	0.5	21.7			

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
ALK	21FLGFWF03090101-LM-01	2/7/2005	0	0.5	23.0			
ALK	21FLGFWF03090101-LM-01	5/2/2005	0	0.5	24.0			
ALK	21FLGFWF03090101-LM-01	8/8/2005	1445	0.1	23.5			
ALK	21FLGFWF03090101-LM-01	12/5/2005	1240	0.1	19.0			
ALK	21FLGFWF03090101-LM-01	2/13/2006	1600	0.5	18.0			
ALK	21FLGFWF03090101-LM-01	5/8/2006	1350	2.5	22.0			
ALK	21FLGFWF03090101-LM-01	8/7/2006	1430	0.1	28.0			
ALK	21FLGFWF03090101-LM-01	11/6/2006	1310	0.1	30.0			
ALK	21FLGFWF03090101-LM-01	2/5/2007	1325	0.1	31.0			
ALK	21FLGFWF03090101-LM-01	5/7/2007	1207	0.1	34.0			
ALK	21FLGFWF03090101-LM-01	8/13/2007	1518	0.1	34.0		1	5
ALK	21FLGFWF03090101-LM-01	11/13/2007	1413	0.1	32.0		1	5
ALK	21FLGFWF03090101-LM-01	2/11/2008	1300	0.1	32.0		1	5
ALK	21FLGFWF03090101-LM-01	5/5/2008	1413	0.1	34.0		1	5
ALK	21FLCEN 26011014	2/10/2009	950	0.5	28.0		0.65	2.5
ALK	21FLCEN 26011014	2/10/2009	951	0.5	27.0		0.65	2.5
ALK	21FLCEN 26011013	2/10/2009	1000	0.5	28.0		0.65	2.5
ALK	21FLCEN 26010952	2/10/2009	1010	0.5	27.0		0.65	2.5
ALK	21FLCEN 26010952	5/27/2009	931	0.5	30.0		0.65	2.5
ALK	21FLCEN 26011013	5/27/2009	942	0.5	30.0		0.65	2.5
ALK	21FLCEN 26011014	5/27/2009	956	0.5	30.0		0.65	2.5
ALK	21FLCEN 26010952	7/29/2009	928	0.5	29.0		0.65	2.5
ALK	21FLCEN 26011013	7/29/2009	938	0.5	29.0	A	0.65	2.5
ALK	21FLCEN 26011014	7/29/2009	951	0.5	29.0		0.65	2.5
ALK	21FLCEN 26011014	7/29/2009	952	0.5	29.0		0.65	2.5

pH

Parameter	Station	Date	Time	Depth	Result (S.U.)	rcode	mdl	pql
PH	112WRD 02268800	5/24/1966			5.9			
PH	112WRD 02268800	8/9/1966			6.5			
PH	112WRD 02268800	5/8/1967			6.2			
PH	112WRD 02268800	4/18/1968	1645		6.5			
PH	112WRD 02268800	4/2/1970	1230		7.3			
PH	112WRD 02268800	8/31/1970	1130		6.7			
PH	112WRD 02268800	9/2/1971	1330		6.5			
PH	112WRD 02268800	4/19/1972	1045		7			
PH	112WRD 02268800	10/4/1972	1215		7			
PH	112WRD 02268800	4/25/1973	1000		6.7			
PH	112WRD 02268800	10/30/1973	1125		6.3			
PH	112WRD 02268800	4/29/1974	1255		7.1			
PH	112WRD 02268800	8/19/1974	1110		6.3			
PH	112WRD 02268800	10/15/1974	1005		6.5			
PH	112WRD 02268800	12/10/1974	1220		6.1			
PH	112WRD 02268800	2/3/1975	1200		6.2			
PH	112WRD 02268800	3/31/1975	1200		6.4			
PH	112WRD 02268800	5/28/1975	1000		6.6			
PH	112WRD 02268800	7/28/1975	1125		5.7			
PH	112WRD 02268800	9/15/1975	925		6.5			
PH	112WRD 02268800	2/10/1976	1240		7.7			
PH	21FLA 26010952	3/10/1976	1300	6	8.4			
PH	112WRD 02268800	4/20/1976	1445		8.4			
PH	112WRD 02268800	9/22/1976	1455		7.1			
PH	112WRD 02268800	1/26/1977	1238		7.8			
PH	112WRD 02268800	5/17/1977	1130		8			
PH	112WRD 02268800	8/29/1977	1040		7.9			
PH	112WRD 02268800	2/22/1978	1450		7.4			
PH	112WRD 02268800	2/22/1978	1451		7.4			
PH	112WRD 02268800	2/22/1978	1452		7.3			
PH	112WRD 02268800	2/22/1978	1453		7.3			
PH	112WRD 02268800	2/22/1978	1454		7.3			
PH	112WRD 02268800	2/22/1978	1455		7.3			
PH	112WRD 02268800	2/22/1978	1456		7.3			
PH	112WRD 02268800	5/23/1978	1030		8.2			
PH	112WRD 02268800	8/30/1978	1525		7.7			
PH	112WRD 02268800	8/30/1978	1526		7.8			
PH	112WRD 02268800	8/30/1978	1527		7.6			
PH	112WRD 02268800	8/30/1978	1528		6.8			

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Parameter	Station	Date	Time	Depth	Result (S.U.)	rcode	mdl	pql
PH	112WRD 02268800	8/30/1978	1529		6.5			
PH	112WRD 02268800	8/30/1978	1530		6.4			
PH	112WRD 02268800	8/30/1978	1531		6.4			
PH	112WRD 02268800	8/30/1978	1532		6.3			
PH	21FLA 26010952	9/7/1978	1045	4	8.9			
PH	112WRD 02268800	3/28/1979	1250		7.5			
PH	112WRD 02268800	5/30/1979	1500		6.2			
PH	21FLA 26010952	9/24/1979	1015	9	7.1			
PH	112WRD 02268800	1/15/1980	1155		6.8			
PH	112WRD 02268800	4/30/1980	1430		8.5			
PH	112WRD 02268800	9/5/1980	1340		6.6			
PH	21FLA 26010952	10/9/1980	1030	0	7.45			
PH	21FLA 26010952	12/15/1980	1115	0	8.66			
PH	21FLA 26010952	12/15/1980	1115	6	8.05			
PH	112WRD 02268800	2/18/1981	1230		7.2			
PH	112WRD 02268800	4/29/1981	1115		6.9			
PH	21FLA 26010952	6/9/1981	1300	1	8.3			
PH	21FLA 26010952	6/9/1981	1300	6	6.6			
PH	21FLA 26010952	6/9/1981	1300	13	8			
PH	112WRD 02268800	8/26/1981	1035		7.8			
PH	112WRD 02268800	3/10/1982	1130		7.1			
PH	112WRD 02268800	6/2/1982	1105		5.6			
PH	112WRD 02268800	9/4/1982	1530		6.8			
PH	112WRD 02268800	9/4/1982	1535		8.8			
PH	112WRD 02268800	3/30/1983	935		8.2			
PH	112WRD 02268800	5/26/1983	1325		8.9			
PH	112WRD 02268800	8/26/1983	1630		7			
PH	21FLA 26010952	1/15/1985	844	6	7.8			
PH	21FLA 26010952	9/24/1985	830	7	6.8			
PH	21FLA 26010952	11/10/1987	815	8	7.5			
PH	21FLA 26010952	2/16/1988	835	7	7.4			
PH	21FLA 26010952	5/24/1988	905	2	8.7			
PH	21FLA 26010952	7/18/1988	815	2	8.1			
PH	21FLA 26010952	7/26/1993	825	6.56	7.8			
PH	21FLSFWMFDEP02	9/22/1993	850	0.5	8.68			
PH	21FLSFWMFDEP01	9/22/1993	940	0.5	7.14			
PH	21FLA 26010952	10/11/1993	855	6.56	7.3			
PH	21FLA 26010952	1/24/1994	845	6.56	7.4			
PH	21FLA 26010952	4/11/1994	915	6.56	7.1			
PH	21FLA 26010952	7/18/1994	1513	6.56	7.7			
PH	21FLSFWMFDEP01	10/4/1994	1700	0.5	7.94		1	
PH	21FLSFWMFDEP02	10/4/1994	1715	0.5	6.75		1	

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Parameter	Station	Date	Time	Depth	Result (S.U.)	rcode	mdl	pql
PH	21FLA 26010952	10/24/1994	933	6.56	6.95			
PH	21FLA 26010952	1/30/1995	1330	6.56	6.87			
PH	21FLA 26010952	4/10/1995	925	6.56	7			
PH	21FLA 26010952	8/14/1995	1452	7.87	7.96			
PH	21FLA 26010952	10/16/1995	1305	7.87	6.8			
PH	21FLA 26010952	1/22/1996	1335	7.71	7.2			
PH	21FLGFWFGCCR0590	2/5/1996	1545	0	6	D		
PH	21FLGFWF03090101-LM-01	2/5/1996	1545	0	6			
PH	21FLA 26010952	4/1/1996	1434	7.54	7.36			
PH	21FLGFWFGCCR0590	5/6/1996	1505	0	7.1	D		
PH	21FLGFWF03090101-LM-01	5/6/1996	1505	0	7.1			
PH	21FLA 26010952	7/8/1996	852	7.54	7.8			
PH	21FLA 26010952	7/8/1996	857	7.54	7.06			
PH	21FLGFWF03090101-LM-01	8/5/1996	1615	0	9			
PH	21FLA 26010952	10/28/1996	945	7.22	7.09			
PH	21FLGFWF03090101-LM-01	11/4/1996	1520	0	7.3			
PH	21FLA 26010952	1/21/1997	950	6.56	8.36			
PH	21FLGFWF03090101-LM-01	2/3/1997	1525	0	9.4			
PH	21FLA 26010952	4/7/1997	1018	6.72	8.35			
PH	21FLA 26010952	4/7/1997	1023	6.89	8.59			
PH	21FLGFWF03090101-LM-01	5/5/1997		0	7.4			
PH	21FLA 26010952	8/4/1997	1345	5.25	7.83			
PH	21FLGFWF03090101-LM-01	8/4/1997	1752	0	7.6			
PH	21FLA 26010952	10/13/1997	1015	7.54	7.47			
PH	21FLGFWF03090101-LM-01	11/3/1997	1615	0	8			
PH	21FLA 26010952	1/20/1998	1035	7.87	7.26			
PH	21FLA 26010952	4/13/1998	955	7.54	7.75			
PH	21FLA 26010952	7/6/1998	948	8.2	7.53			
PH	21FLGFWF03090101-LM-01	8/3/1998		0	9			
PH	21FLGFWF03090101-LM-01	11/2/1998	1545	0	9.6			
PH	21FLGFWF03090101-LM-01	2/1/1999	1130	0	6.6			

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Parameter	Station	Date	Time	Depth	Result (S.U.)	rcode	mdl	pql
PH	21FLGFWF03090101-LM-01	5/3/1999	1320	0	9.3			
PH	21FLCEN 26011014	9/27/1999	0	0.3	7.7		3	
PH	21FLCEN 26011012	9/27/1999	0	0.3	7.6		3	
PH	21FLCEN 26011013	9/27/1999	0	0.3	7.8		3	
PH	21FLGFWF03090101-LM-01	10/15/1999	1059	0	7.3			
PH	21FLGFWF03090101-LM-01	2/7/2000	1231	0	7.4			
PH	21FLGFWF03090101-LM-01	5/15/2000	930	0	8.1			
PH	21FLGFWF03090101-LM-01	8/14/2000	900	0	8.1			
PH	21FLGFWF03090101-LM-01	11/13/2000	1000	0	7.4			
PH	21FLGFWF03090101-LM-01	2/12/2001	830	0	7.5			
PH	21FLGFWF03090101-LM-01	12/3/2001		0	6.4			
PH	21FLGFWF03090101-LM-01	2/4/2002	1315	0	6.6			
PH	21FLGFWF03090101-LM-01	5/6/2002	1015	0.5	7.1			
PH	21FLGFWF03090101-LM-01	8/5/2002	815	0	6.8			
PH	21FLGFWF03090101-LM-01	10/28/2002	900	0.5	7.3		1	
PH	21FLGFWF03090101-LM-01	2/10/2003	700	0.5	6.4			
PH	21FLGFWF03090101-LM-01	5/5/2003	1000	0.5	6.8			
PH	21FLGFWF03090101-LM-01	8/25/2003	920	0.5	6.6			
PH	21FLGFWF03090101-LM-01	11/3/2003	930	0.5	6.3			
PH	21FLGFWF03090101-LM-01	2/9/2004	1500	0.5	8			
PH	21FLGFWF03090101-LM-01	5/10/2004	0	0.1	8			
PH	21FLGFWF03090101-LM-01	11/15/2004	1410	0.5	6.6			
PH	21FLGFWF03090101-LM-01	2/7/2005	0	0.5	7.5			
PH	21FLGFWF03090101-LM-01	5/2/2005	0	0.5	8.6			
PH	21FLGFWF03090101-LM-01	8/8/2005	1445	0.1	8.9			

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Parameter	Station	Date	Time	Depth	Result (S.U.)	rcode	mdl	pql
PH	21FLGFWF03090101-LM-01	12/5/2005	1240	0.1	7.4			
PH	21FLGFWF03090101-LM-01	2/13/2006	1600	0.5	6.9			
PH	21FLGFWF03090101-LM-01	5/8/2006	1350	2.5	9			
PH	21FLGFWF03090101-LM-01	8/7/2006	1430	0.1	9.2			
PH	21FLGFWF03090101-LM-01	11/6/2006	1310	0.1	9.6			
PH	21FLGFWF03090101-LM-01	2/5/2007	1325	0.1	10.8			
PH	21FLGFWF03090101-LM-01	5/7/2007	1207	0.1	7.9			
PH	21FLGFWF03090101-LM-01	8/13/2007	1518	0.1	9			
PH	21FLGFWF03090101-LM-01	11/13/2007	1413	0.1	8			
PH	21FLGW 34147	12/19/2007	1018	1.4	7.2			
PH	21FLGW 34147	12/19/2007	1020	0.3	7.7			
PH	21FLGFWF03090101-LM-01	2/11/2008	1300	0.1	7.4			
PH	21FLGFWF03090101-LM-01	5/5/2008	1413	0.1	9.1			
PH	21FLCEN 26011014	2/10/2009	950	0.5	7.8			
PH	21FLCEN 26011014	2/10/2009	951	0.5	7.8			
PH	21FLCEN 26011013	2/10/2009	1000	0.5	7.6			
PH	21FLCEN 26010952	2/10/2009	1010	0.5	8.1			
PH	21FLCEN 26011183	2/17/2009	1104	0.5	8			
PH	21FLCEN 26011183	2/17/2009	1106	0.5	8			
PH	21FLCEN 26011184	2/17/2009	1114	0.5	7.6			
PH	21FLCEN 26011185	2/17/2009	1129	0.5	8			
PH	21FLCEN 26010952	5/27/2009	931	0.5	8.9			
PH	21FLCEN 26011013	5/27/2009	942	0.5	8.7			
PH	21FLCEN 26011014	5/27/2009	956	0.5	8.8			
PH	21FLCEN 26010952	7/29/2009	928	0.5	7.9			
PH	21FLCEN 26011013	7/29/2009	938	0.5	7.2			
PH	21FLCEN 26011014	7/29/2009	951	0.5	7			
PH	21FLCEN 26011014	7/29/2009	952	0.5	7			

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Parameter	Station	Date	Time	Depth	Result (meters)	rcode	mdl	pql
SD	112WRD 02268800	2/10/1976	1240		0.90			
SD	21FLA 26010952	3/10/1976	1300	6	0.80			
SD	112WRD 02268800	4/20/1976	1445		0.75			
SD	112WRD 02268800	9/22/1976	1455		0.85			
SD	112WRD 02268800	1/26/1977	1238		0.75			
SD	112WRD 02268800	5/17/1977	1130		0.73			
SD	112WRD 02268800	8/29/1977	1040		0.63			
SD	21FLA 26010952	9/7/1977	1127	0	0.70			
SD	112WRD 02268800	2/22/1978	1450		0.65			
SD	112WRD 02268800	5/23/1978	1030		0.90			
SD	112WRD 02268800	8/30/1978	1525		0.83			
SD	21FLA 26010952	9/7/1978	1045	0	0.70			
SD	112WRD 02268800	5/30/1979	1500		0.60			
SD	21FLA 26010952	9/24/1979	1015	0	0.50			
SD	112WRD 02268800	1/15/1980	1155		0.65			
SD	112WRD 02268800	4/30/1980	1430		0.55			
SD	112WRD 02268800	9/5/1980	1340		0.35			
SD	21FLA 26010952	10/9/1980	1030	0	0.35			
SD	21FLA 26010952	12/15/1980	1115	0	0.60			
SD	112WRD 02268800	2/18/1981	1230		0.50			
SD	112WRD 02268800	4/29/1981	1115		0.75			
SD	112WRD 02268800	8/26/1981	1035		0.53			
SD	112WRD 02268800	3/10/1982	1130		0.50			
SD	112WRD 02268800	9/4/1982	1530		0.75			
SD	21FLA 26010952	1/15/1985	844	1	0.60			
SD	21FLA 26010952	1/15/1985	844	6	0.60			
SD	21FLA 26010952	9/24/1985	830	1	0.70			
SD	21FLA 26010952	9/24/1985	830	7	0.70			
SD	21FLA 26010952	11/10/1987	815	8	0.70			
SD	21FLA 26010952	2/16/1988	835	7	0.80			
SD	21FLA 26010952	5/24/1988	905	2	0.50			
SD	21FLA 26010952	7/18/1988	815	2	0.50			
SD	21FLA 26010952	7/26/1993	825	6.56	0.60			
SD	21FLA 26010952	10/11/1993	855	6.56	0.40			
SD	21FLA 26010952	1/24/1994	845	6.56	0.70			
SD	21FLA 26010952	4/11/1994	915	6.56	0.70			
SD	21FLA 26010952	7/18/1994	1513	6.56	0.70			
SD	21FLSFWMFDEP01	10/4/1994	1700	0.5	0.78			
SD	21FLSFWMFDEP02	10/4/1994	1715	0.5	0.68			

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Parameter	Station	Date	Time	Depth	Result (meters)	rcode	mdl	pql
SD	21FLA 26010952	10/24/1994	933	6.56	0.80			
SD	21FLA 26010952	1/30/1995	1330	6.56	1.10			
SD	21FLA 26010952	4/10/1995	925	6.56	0.80			
SD	21FLA 26010952	8/14/1995	1452	7.87	0.80			
SD	21FLA 26010952	10/16/1995	1305	7.87	0.70			
SD	21FLA 26010952	1/22/1996	1335	7.71	0.80			
SD	21FLGFWFGFCCR0590	2/5/1996	1545	0	0.70	D		
SD	21FLGFWF03090101-LM-01	2/5/1996	1545	0	0.70			
SD	21FLA 26010952	4/1/1996	1434	7.54	0.60			
SD	21FLGFWFGFCCR0590	5/6/1996	1505	0	0.90	D		
SD	21FLGFWF03090101-LM-01	5/6/1996	1505	0	0.90			
SD	21FLA 26010952	7/8/1996	852	7.54	0.50			
SD	21FLGFWF03090101-LM-01	8/5/1996	1615	0	0.40			
SD	21FLA 26010952	10/28/1996	945	7.22	0.60			
SD	21FLGFWF03090101-LM-01	11/4/1996	1520	0	0.50			
SD	21FLA 26010952	1/21/1997	950	6.56	0.50			
SD	21FLGFWF03090101-LM-01	2/3/1997	1525	0	1.30			
SD	21FLA 26010952	4/7/1997	1018	3.44	0.40			
SD	21FLA 26010952	4/7/1997	1018	6.72	0.40			
SD	21FLA 26010952	4/7/1997	1023	3.44	0.40			
SD	21FLGFWF03090101-LM-01	5/5/1997		0	0.60			
SD	21FLA 26010952	8/4/1997	1345	5.25	0.40			
SD	21FLGFWF03090101-LM-01	8/4/1997	1752	0	0.50			
SD	21FLA 26010952	10/13/1997	1015	7.54	0.50			
SD	21FLGFWF03090101-LM-01	11/3/1997	1615	0	0.70			
SD	21FLA 26010952	1/20/1998	1035	7.87	0.60			
SD	21FLA 26010952	4/13/1998	955	7.54	0.50			
SD	21FLGFWF03090101-LM-01	5/4/1998		0	4.00			
SD	21FLA 26010952	7/6/1998	948	8.2	0.60			
SD	21FLGFWF03090101-LM-01	8/3/1998		0	0.50			
SD	21FLGFWF03090101-LM-01	11/2/1998	1545	0	0.50			
SD	21FLGFWF03090101-LM-01	2/1/1999	1130	0	0.45			

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Parameter	Station	Date	Time	Depth	Result (meters)	rcode	mdl	pql
SD	21FLGFWF03090101-LM-01	5/3/1999	1320	0	0.61			
SD	21FLGFWF03090101-LM-01	8/2/1999	1410	0	0.61			
SD	21FLCEN 26011014	9/27/1999	0	0.3	0.50			
SD	21FLCEN 26011012	9/27/1999	0	0.3	0.50			
SD	21FLCEN 26011013	9/27/1999	0	0.3	0.50			
SD	21FLGFWF03090101-LM-01	10/15/1999	1059	0	0.61			
SD	21FLGFWF03090101-LM-01	2/7/2000	1231	0	0.90			
SD	21FLGFWF03090101-LM-01	5/15/2000	930	0	1.10			
SD	21FLGFWF03090101-LM-01	8/14/2000	900	0	0.80			
SD	21FLGFWF03090101-LM-01	11/13/2000	1000	0	0.70			
SD	21FLGFWF03090101-LM-01	2/12/2001	830	0	0.60			
SD	21FLGFWF03090101-LM-01	12/3/2001		0	0.60			
SD	21FLGFWF03090101-LM-01	2/4/2002	1315	0	0.60			
SD	21FLGFWF03090101-LM-01	5/6/2002	1015	0.5	0.40			
SD	21FLGFWF03090101-LM-01	8/5/2002	815	0	0.70			
SD	21FLGFWF03090101-LM-01	10/28/2002	900	0.5	1.00			
SD	21FLGFWF03090101-LM-01	2/10/2003	700	0.5	0.80			
SD	21FLGFWF03090101-LM-01	5/5/2003	1000	0.5	0.60			
SD	21FLGFWF03090101-LM-01	8/25/2003	920	0.5	0.70			
SD	21FLGFWF03090101-LM-01	11/3/2003	930	0.5	0.50			
SD	21FLGFWF03090101-LM-01	2/9/2004	1500	0.5	0.60			
SD	21FLGFWF03090101-LM-01	5/10/2004	0	0.1	0.60			
SD	21FLGFWF03090101-LM-01	11/15/2004	1410	0.5	0.61			
SD	21FLGFWF03090101-LM-01	2/7/2005	0	0.5	0.40			
SD	21FLGFWF03090101-LM-01	5/2/2005	0	0.5	0.40			

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Parameter	Station	Date	Time	Depth	Result (meters)	rcode	mdl	pql
SD	21FLGFWF03090101-LM-01	8/8/2005	1445	0.1	0.60			
SD	21FLGFWF03090101-LM-01	12/5/2005	1240	0.1	0.70			
SD	21FLGFWF03090101-LM-01	2/13/2006	1600	0.5	0.50			
SD	21FLGFWF03090101-LM-01	5/8/2006	1350	2.5	0.50			
SD	21FLGFWF03090101-LM-01	8/7/2006	1430	0.1	0.30			
SD	21FLGFWF03090101-LM-01	11/6/2006	1310	0.1	0.30			
SD	21FLGFWF03090101-LM-01	2/5/2007	1325	0.1	2.50			
SD	21FLGFWF03090101-LM-01	5/7/2007	1207	0.1	0.50			
SD	21FLGFWF03090101-LM-01	8/13/2007	1518	0.1	0.40			
SD	21FLGFWF03090101-LM-01	11/13/2007	1413	0.1	0.40			
SD	21FLGW 34147	12/19/2007	1020	0.3	0.60			
SD	21FLGFWF03090101-LM-01	2/11/2008	1300	0.1	0.40			
SD	21FLGFWF03090101-LM-01	5/5/2008	1413	0.1	0.40			
SD	21FLCEN 26011014	2/10/2009	950	0.5	0.90			
SD	21FLCEN 26011014	2/10/2009	951	0.5	0.90			
SD	21FLCEN 26011013	2/10/2009	1000	0.5	0.90			
SD	21FLCEN 26010952	2/10/2009	1010	0.5	0.80			
SD	21FLCEN 26011183	2/17/2009	1104	0.5	0.90			
SD	21FLCEN 26011183	2/17/2009	1106	0.5	0.90			
SD	21FLCEN 26011184	2/17/2009	1114	0.5	0.60			
SD	21FLCEN 26011185	2/17/2009	1129	0.5	0.60			
SD	21FLCEN 26010952	5/27/2009	931	0.5	0.40			
SD	21FLCEN 26011013	5/27/2009	942	0.5	0.40			
SD	21FLCEN 26011014	5/27/2009	956	0.5	0.40			
SD	21FLCEN 26010952	7/29/2009	928	0.5	0.60			
SD	21FLCEN 26011013	7/29/2009	938	0.5	0.60			
SD	21FLCEN 26011014	7/29/2009	951	0.5	0.60			
SD	21FLCEN 26011014	7/29/2009	952	0.5	0.60			

Color

Parameter	Station	Date	Time	Depth	Result (PCU)	rcode	mdl	pql
COLOR	112WRD 02268800	5/24/1966			40			
COLOR	112WRD 02268800	8/9/1966			50			
COLOR	112WRD 02268800	5/8/1967			40			
COLOR	112WRD 02268800	4/18/1968	1645		45			
COLOR	112WRD 02268800	4/2/1970	1230		45			
COLOR	112WRD 02268800	8/31/1970	1130		40			
COLOR	112WRD 02268800	9/2/1971	1330		30			
COLOR	112WRD 02268800	4/19/1972	1045		20			
COLOR	112WRD 02268800	10/4/1972	1215		40			
COLOR	112WRD 02268800	4/25/1973	1000		50			
COLOR	112WRD 02268800	10/30/1973	1125		90			
COLOR	112WRD 02268800	4/29/1974	1255		50			
COLOR	112WRD 02268800	10/15/1974	1005		100			
COLOR	112WRD 02268800	5/28/1975	1000		48			
COLOR	112WRD 02268800	9/15/1975	925		30			
COLOR	112WRD 02268800	4/20/1976	1445		60			
COLOR	112WRD 02268800	5/17/1977	1130		30			
COLOR	112WRD 02268800	8/29/1977	1040		30			
COLOR	112WRD 02268800	5/23/1978	1030		50			
COLOR	112WRD 02268800	5/30/1979	1500		50			
COLOR	112WRD 02268800	4/30/1980	1430		40			
COLOR	21FLA 26010952	12/15/1980	1115	6	60			
COLOR	112WRD 02268800	4/29/1981	1115		30			
COLOR	21FLA 26010952	6/9/1981	1300	6	25			
COLOR	112WRD 02268800	6/2/1982	1105		40			
COLOR	112WRD 02268800	9/4/1982	1530		80			
COLOR	112WRD 02268800	5/26/1983	1325		45			
COLOR	112WRD 02268800	8/26/1983	1630		40			
COLOR	21FLA 26010952	1/15/1985	844	6	20			
COLOR	21FLA 26010952	9/24/1985	830	7	80			
COLOR	21FLA 26010952	11/10/1987	815	8	60			
COLOR	21FLA 26010952	2/16/1988	835	7	60			
COLOR	21FLA 26010952	5/24/1988	905	2	105			
COLOR	21FLA 26010952	7/18/1988	815	2	40			
COLOR	21FLA 26010952	7/26/1993	825	6.56	60			
COLOR	21FLSFWMFDEP02	9/22/1993	850	0.5	20			
COLOR	21FLSFWMFDEP01	9/22/1993	940	0.5	19			
COLOR	21FLA 26010952	10/11/1993	855	6.56	40			
COLOR	21FLA 26010952	1/24/1994	845	6.56	40			

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Parameter	Station	Date	Time	Depth	Result (PCU)	rcode	mdl	pql
COLOR	21FLA 26010952	4/11/1994	915	6.56	30			
COLOR	21FLA 26010952	7/18/1994	1513	6.56	40			
COLOR	21FLSFWMFDEP01	10/4/1994	1700	0.5	63			
COLOR	21FLSFWMFDEP02	10/4/1994	1715	0.5	99			
COLOR	21FLA 26010952	10/24/1994	933	6.56	80			
COLOR	21FLA 26010952	1/30/1995	1330	6.56	80			
COLOR	21FLA 26010952	4/10/1995	925	6.56	80			
COLOR	21FLA 26010952	8/14/1995	1452	7.87	80			
COLOR	21FLA 26010952	10/16/1995	1305	7.87	80			
COLOR	21FLA 26010952	1/22/1996	1335	7.71	80			
COLOR	21FLA 26010952	4/1/1996	1434	7.54	80			
COLOR	21FLA 26010952	7/8/1996	852	7.54	60			
COLOR	21FLA 26010952	7/8/1996	857	7.54	60			
COLOR	21FLA 26010952	10/28/1996	945	7.22	60			
COLOR	21FLA 26010952	1/21/1997	950	6.56	60			
COLOR	21FLA 26010952	4/7/1997	1018	6.72	40			
COLOR	21FLA 26010952	4/7/1997	1023	6.89	40			
COLOR	21FLA 26010952	8/4/1997	1345	5.25	80			
COLOR	21FLA 26010952	10/13/1997	1015	7.54	80			
COLOR	21FLA 26010952	1/20/1998	1035	7.87	100			
COLOR	21FLA 26010952	4/13/1998	955	7.54	150			
COLOR	21FLA 26010952	7/6/1998	948	8.2	80			
COLOR	21FLCEN 26011014	9/27/1999	0	0.3	80			
COLOR	21FLCEN 26011012	9/27/1999	0	0.3	80			
COLOR	21FLCEN 26011013	9/27/1999	0	0.3	80			
COLOR	21FLGW 34147	12/19/2007	1020	0.3	100		10	10
COLOR	21FLCEN 26011014	2/10/2009	950	0.5	100		10	10
COLOR	21FLCEN 26011014	2/10/2009	951	0.5	100		10	10
COLOR	21FLCEN 26011013	2/10/2009	1000	0.5	100	A	10	10
COLOR	21FLCEN 26010952	2/10/2009	1010	0.5	100		10	10
COLOR	21FLCEN 26010952	5/27/2009	931	0.5	100		25	25
COLOR	21FLCEN 26011013	5/27/2009	942	0.5	100		25	25
COLOR	21FLCEN 26011014	5/27/2009	956	0.5	100		25	25
COLOR	21FLCEN 26010952	7/29/2009	928	0.5	120		10	10
COLOR	21FLCEN 26011013	7/29/2009	938	0.5	120	A	10	10
COLOR	21FLCEN 26011014	7/29/2009	951	0.5	120		10	10
COLOR	21FLCEN 26011014	7/29/2009	952	0.5	120		10	10

Total Nitrogen

Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TN	112WRD 02268800	9/2/1971	1330		1.12	+		
TN	112WRD 02268800	10/19/1971	1230		2.36	+		
TN	112WRD 02268800	12/28/1971	1100		4.17	+		
TN	112WRD 02268800	3/8/1972	1120		2.35	+		
TN	112WRD 02268800	4/19/1972	1045		1.92	+		
TN	112WRD 02268800	6/27/1972	1100		1.36	+		
TN	112WRD 02268800	8/29/1972	1210		1.66	+		
TN	112WRD 02268800	10/4/1972	1215		0.96	+		
TN	112WRD 02268800	10/31/1972	1210		1.84	+		
TN	112WRD 02268800	12/26/1972	1130		2.47	+		
TN	112WRD 02268800	2/26/1973	1315		1.09	+		
TN	112WRD 02268800	4/25/1973	1000		1.09	+		
TN	112WRD 02268800	6/25/1973	1500		1.91	+		
TN	112WRD 02268800	8/27/1973	1100		1.83	+		
TN	112WRD 02268800	10/30/1973	1125		1.60			
TN	112WRD 02268800	12/18/1973	915		5.69	+		
TN	112WRD 02268800	2/27/1974	1130		1.80			
TN	112WRD 02268800	4/29/1974	1255		1.60			
TN	112WRD 02268800	6/24/1974	1010		3.28			
TN	112WRD 02268800	8/19/1974	1110		1.74			
TN	112WRD 02268800	10/15/1974	1005		1.41			
TN	112WRD 02268800	12/10/1974	1220		2.46			
TN	112WRD 02268800	2/3/1975	1200		2.67			
TN	112WRD 02268800	3/31/1975	1200		3.08			
TN	112WRD 02268800	5/28/1975	1000		2.46			
TN	112WRD 02268800	7/28/1975	1125		2.26			
TN	112WRD 02268800	9/15/1975	925		1.58			
TN	112WRD 02268800	2/10/1976	1240		1.37			
TN	21FLA 26010952	3/10/1976	1300	6	0.63	+		
TN	112WRD 02268800	4/20/1976	1445		1.82			
TN	112WRD 02268800	9/22/1976	1455		1.68			
TN	112WRD 02268800	1/26/1977	1238		1.82			
TN	112WRD 02268800	5/17/1977	1130		1.99			
TN	112WRD 02268800	8/29/1977	1040		1.48			
TN	21FLA 26010952	9/7/1977	1127	0	1.69	+		
TN	112WRD 02268800	2/22/1978	1450		2.26			
TN	112WRD 02268800	5/23/1978	1030		1.39			
TN	112WRD 02268800	8/30/1978	1525		1.37			
TN	21FLA 26010952	9/7/1978	1045	4	1.20			

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TN	112WRD 02268800	3/28/1979	1250		1.52			
TN	112WRD 02268800	5/30/1979	1500		3.69			
TN	21FLA 26010952	9/24/1979	1015	9	1.42			
TN	112WRD 02268800	1/15/1980	1155		1.52			
TN	112WRD 02268800	4/30/1980	1430		1.58			
TN	112WRD 02268800	9/5/1980	1340		2.26			
TN	21FLA 26010952	10/9/1980	1030	7	2.15	+		
TN	21FLA 26010952	12/15/1980	1115	6	1.71	+		
TN	112WRD 02268800	2/18/1981	1230		1.39			
TN	112WRD 02268800	4/29/1981	1115		1.66			
TN	21FLA 26010952	6/9/1981	1300	6	1.66	+		
TN	112WRD 02268800	8/26/1981	1035		1.11			
TN	112WRD 02268800	3/10/1982	1130		1.64			
TN	112WRD 02268800	6/2/1982	1105		1.29			
TN	112WRD 02268800	9/4/1982	1530		1.68			
TN	112WRD 02268800	3/30/1983	935		1.37			
TN	112WRD 02268800	5/26/1983	1325		1.11			
TN	112WRD 02268800	8/26/1983	1630		1.51	+		
TN	21FLA 26010952	1/15/1985	844	6	1.56	+		
TN	21FLA 26010952	9/24/1985	830	7	1.68	+		
TN	21FLA 26010952	11/10/1987	815	8	1.71	+		
TN	21FLA 26010952	2/16/1988	835	7	1.36	+		
TN	21FLA 26010952	5/24/1988	905	2	2.28	+		
TN	21FLA 26010952	7/18/1988	815	2	1.67	+		
TN	21FLA 26010952	7/26/1993	825	6.56	2.12	+		
TN	21FLSFWMFDEP02	9/22/1993	850	0.5	1.76	+		
TN	21FLSFWMFDEP01	9/22/1993	940	0.5	1.32	+		
TN	21FLA 26010952	10/11/1993	855	6.56	2.02	+		
TN	21FLA 26010952	1/24/1994	845	6.56	1.92	+		
TN	21FLA 26010952	4/11/1994	915	6.56	1.91	+		
TN	21FLA 26010952	7/18/1994	1513	6.56	1.60	+		
TN	21FLSFWMFDEP01	10/4/1994	1700	0.5	1.07	+		
TN	21FLSFWMFDEP02	10/4/1994	1715	0.5	1.11	+		
TN	21FLA 26010952	10/24/1994	933	6.56	1.40	+		
TN	21FLA 26010952	1/30/1995	1330	6.56	1.93	+		
TN	21FLA 26010952	4/10/1995	925	6.56	1.25	+		
TN	21FLA 26010952	8/14/1995	1452	7.87	1.61	+		
TN	21FLA 26010952	10/16/1995	1305	7.87	2.18	+		
TN	21FLA 26010952	1/22/1996	1335	7.71	1.29	+		
TN	21FLA 26010952	4/1/1996	1434	7.54	1.51	+		
TN	21FLGFWF03090101-LM-01	5/6/1996	1505	0	0.96	+		
TN	21FLGFWF03090101-LM-01	5/6/1996	1505	0	0.96	+		

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TN	21FLA 26010952	7/8/1996	852	7.54	2.03	+		
TN	21FLA 26010952	7/8/1996	857	7.54	1.83	+		
TN	21FLGFWF03090101-LM-01	8/5/1996	1615	0	1.91	+		
TN	21FLA 26010952	10/28/1996	945	7.22	1.61	+		
TN	21FLGFWF03090101-LM-01	11/4/1996	1520	0	1.99	+		
TN	21FLA 26010952	1/21/1997	950	6.56	1.70	+		
TN	21FLGFWF03090101-LM-01	2/3/1997	1525	0	2.01	+		
TN	21FLA 26010952	4/7/1997	1018	6.72	2.40	+		
TN	21FLA 26010952	4/7/1997	1023	6.89	2.40	+		
TN	21FLA 26010952	8/4/1997	1345	5.25	1.90	+		
TN	21FLGFWF03090101-LM-01	8/4/1997	1752	0	1.88	+		
TN	21FLA 26010952	10/13/1997	1015	7.54	1.70	+		
TN	21FLGFWF03090101-LM-01	11/3/1997	1615	0	1.78	+		
TN	21FLA 26010952	1/20/1998	1035	7.87	1.41	+		
TN	21FLA 26010952	4/13/1998	955	7.54	1.51	+		
TN	21FLGFWF03090101-LM-01	5/4/1998		0	1.16	+		
TN	21FLA 26010952	7/6/1998	948	8.2	1.71	+		
TN	21FLGFWF03090101-LM-01	8/3/1998		0	1.64	+		
TN	21FLGFWF03090101-LM-01	11/2/1998	1545	0	1.79	+		
TN	21FLGFWF03090101-LM-01	2/1/1999	1130	0	2.06	+		
TN	21FLGFWF03090101-LM-01	5/3/1999	1320	0	2.49	+		
TN	21FLGFWF03090101-LM-01	8/2/1999	1410	0	1.72	+		
TN	21FLCEN 26011014	9/27/1999	0	0.3	1.61	+		
TN	21FLCEN 26011012	9/27/1999	0	0.3	1.81	+		
TN	21FLCEN 26011013	9/27/1999	0	0.3	1.51	+		
TN	21FLGFWF03090101-LM-01	10/15/1999	1059	0	2.32	+		
TN	21FLGFWF03090101-LM-01	2/7/2000	1231	0	2.91	+		
TN	21FLGFWF03090101-LM-01	5/15/2000	930	0	1.91	+		
TN	21FLGFWF03090101-LM-01	8/14/2000	900	0	2.31	+		

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TN	21FLGFWF03090101-LM-01	11/13/2000	1000	0	3.19	+		
TN	21FLGFWF03090101-LM-01	2/12/2001	830	0	5.22	+		
TN	21FLGFWF03090101-LM-01	12/3/2001		0	2.04	+		
TN	21FLGFWF03090101-LM-01	2/4/2002	1315	0	2.44	+		
TN	21FLGFWF03090101-LM-01	5/6/2002	1015	0.5	3.07	+		
TN	21FLGFWF03090101-LM-01	8/5/2002	815	0	1.68	+		
TN	21FLGFWF03090101-LM-01	10/28/2002	900	0.5	1.52	+		
TN	21FLGFWF03090101-LM-01	2/10/2003	700	0.5	2.07	+		
TN	21FLGFWF03090101-LM-01	5/5/2003	1000	0.5	1.54	+		
TN	21FLGFWF03090101-LM-01	8/25/2003	920	0.5	1.44	+		
TN	21FLGFWF03090101-LM-01	11/3/2003	930	0.5	2.20	+		
TN	21FLGFWF03090101-LM-01	2/9/2004	1500	0.5	2.72	+		
TN	21FLGFWF03090101-LM-01	5/10/2004	0	0.1	1.95	+		
TN	21FLGFWF03090101-LM-01	11/15/2004	1410	0.5	1.75	+		
TN	21FLGFWF03090101-LM-01	5/2/2005	0	0.5	0.97	+		
TN	21FLGFWF03090101-LM-01	8/8/2005	1445	0.1	0.45	+		
TN	21FLGFWF03090101-LM-01	12/5/2005	1240	0.1	0.50	+		
TN	21FLGFWF03090101-LM-01	5/8/2006	1350	2.5	1.42	+		
TN	21FLGFWF03090101-LM-01	8/7/2006	1430	0.1	2.53	+		
TN	21FLGFWF03090101-LM-01	11/6/2006	1310	0.1	3.05	+		
TN	21FLGFWF03090101-LM-01	2/5/2007	1325	0.1	2.71	+		
TN	21FLGFWF03090101-LM-01	5/7/2007	1207	0.1	0.71	+		
TN	21FLGFWF03090101-LM-01	8/13/2007	1518	0.1	2.21	+		

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TN	21FLGFWF03090101-LM-01	11/13/2007	1413	0.1	1.92	+		
TN	21FLGW 34147	12/19/2007	1020	0.3	2.10	+		
TN	21FLGFWF03090101-LM-01	2/11/2008	1300	0.1	2.33	+		
TN	21FLGFWF03090101-LM-01	5/5/2008	1413	0.1	2.49	+		
TN	21FLCEN 26011014	2/10/2009	950	0.5	1.90	+		
TN	21FLCEN 26011014	2/10/2009	951	0.5	1.69	+		
TN	21FLCEN 26011013	2/10/2009	1000	0.5	1.72	+		
TN	21FLCEN 26010952	2/10/2009	1010	0.5	1.75	+		
TN	21FLCEN 26011183	2/17/2009	1104	0.5	1.83	+		
TN	21FLCEN 26011183	2/17/2009	1106	0.5	1.93	+		
TN	21FLCEN 26011184	2/17/2009	1114	0.5	2.25	+		
TN	21FLCEN 26011185	2/17/2009	1129	0.5	2.33	+		
TN	21FLCEN 26010952	5/27/2009	931	0.5	2.80	+		
TN	21FLCEN 26011013	5/27/2009	942	0.5	3.10	+		
TN	21FLCEN 26011014	5/27/2009	956	0.5	2.80	+		
TN	21FLCEN 26010952	7/29/2009	928	0.5	1.80	+		
TN	21FLCEN 26011013	7/29/2009	938	0.5	2.00	+		
TN	21FLCEN 26011014	7/29/2009	951	0.5	2.00	+		
TN	21FLCEN 26011014	7/29/2009	952	0.5	2.10	+		
TN	21FLCEN 26011184	8/24/2009	953	0.5	2.34	+		

Total Phosphorus

Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TP	112WRD 02268800	4/2/1970	1230		0.068			
TP	112WRD 02268800	8/31/1970	1130		0.068			
TP	112WRD 02268800	11/13/1970	1510		0.042			
TP	112WRD 02268800	1/15/1971	1325		0.049			
TP	112WRD 02268800	3/5/1971	1530		0.072			
TP	112WRD 02268800	5/3/1971	1300		0.065			
TP	112WRD 02268800	6/28/1971	1405		0.055			
TP	112WRD 02268800	9/2/1971	1330		0.049			
TP	112WRD 02268800	10/19/1971	1230		0.049			
TP	112WRD 02268800	12/28/1971	1100		0.052			
TP	112WRD 02268800	3/8/1972	1120		0.050			
TP	112WRD 02268800	4/19/1972	1045		0.045			
TP	112WRD 02268800	6/27/1972	1100		0.032			
TP	112WRD 02268800	8/29/1972	1210		0.040			
TP	112WRD 02268800	10/4/1972	1215		0.180			
TP	112WRD 02268800	10/31/1972	1210		0.051			
TP	112WRD 02268800	12/26/1972	1130		0.075			
TP	112WRD 02268800	2/26/1973	1315		0.006			
TP	112WRD 02268800	4/25/1973	1000		0.006			
TP	112WRD 02268800	6/25/1973	1500		0.085			
TP	112WRD 02268800	8/27/1973	1100		0.140			
TP	112WRD 02268800	10/30/1973	1125		0.110			
TP	112WRD 02268800	12/18/1973	915		0.550			
TP	112WRD 02268800	2/27/1974	1130		0.190			
TP	112WRD 02268800	4/29/1974	1255		0.180			
TP	112WRD 02268800	6/24/1974	1010		0.300			
TP	112WRD 02268800	8/19/1974	1110		0.290			
TP	112WRD 02268800	10/15/1974	1005		0.220			
TP	112WRD 02268800	12/10/1974	1220		0.200			
TP	112WRD 02268800	2/3/1975	1200		0.200			
TP	112WRD 02268800	3/31/1975	1200		0.170			
TP	112WRD 02268800	5/28/1975	1000		0.110			
TP	112WRD 02268800	7/28/1975	1125		0.110			
TP	112WRD 02268800	9/15/1975	925		0.150			
TP	112WRD 02268800	2/10/1976	1240		0.060			
TP	112WRD 02268800	4/20/1976	1445		0.060			
TP	112WRD 02268800	9/22/1976	1455		0.100			
TP	112WRD 02268800	1/26/1977	1238		0.070			
TP	112WRD 02268800	5/17/1977	1130		0.080			

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TP	112WRD 02268800	8/29/1977	1040		0.080			
TP	21FLA 26010952	9/7/1977	1127	0	0.063			
TP	112WRD 02268800	2/22/1978	1450		0.170			
TP	112WRD 02268800	5/23/1978	1030		0.060			
TP	112WRD 02268800	8/30/1978	1525		0.110			
TP	21FLA 26010952	9/7/1978	1047	4	0.170			
TP	112WRD 02268800	3/28/1979	1250		0.070			
TP	112WRD 02268800	5/30/1979	1500		0.110			
TP	21FLA 26010952	9/24/1979	1015	9	0.132			
TP	112WRD 02268800	1/15/1980	1155		0.080			
TP	112WRD 02268800	4/30/1980	1430		0.090			
TP	112WRD 02268800	9/5/1980	1340		0.290			
TP	21FLA 26010952	10/9/1980	1030	7	0.096			
TP	21FLA 26010952	12/15/1980	1115	6	0.093			
TP	112WRD 02268800	2/18/1981	1230		0.060			
TP	112WRD 02268800	4/29/1981	1115		0.080			
TP	21FLA 26010952	6/9/1981	1300	6	0.068			
TP	112WRD 02268800	8/26/1981	1035		0.050			
TP	112WRD 02268800	3/10/1982	1130		0.050			
TP	112WRD 02268800	6/2/1982	1105		0.040			
TP	112WRD 02268800	9/4/1982	1530		0.090			
TP	112WRD 02268800	3/30/1983	935		0.100			
TP	112WRD 02268800	5/26/1983	1325		0.110			
TP	112WRD 02268800	8/26/1983	1630		0.050			
TP	21FLA 26010952	1/15/1985	844	6	0.080			
TP	21FLA 26010952	9/24/1985	830	7	0.090			
TP	21FLA 26010952	11/10/1987	815	8	0.120			
TP	21FLA 26010952	2/16/1988	835	7	0.090			
TP	21FLA 26010952	5/24/1988	905	2	0.120			
TP	21FLA 26010952	7/18/1988	815	2	0.130			
TP	21FLA 26010952	7/26/1993	825	6.56	0.091			
TP	21FLSFWMFDEP02	9/22/1993	850	0.5	0.085			
TP	21FLSFWMFDEP01	9/22/1993	940	0.5	0.101			
TP	21FLA 26010952	10/11/1993	855	6.56	0.100			
TP	21FLA 26010952	1/24/1994	845	6.56	0.100			
TP	21FLA 26010952	4/11/1994	915	6.56	0.047			
TP	21FLA 26010952	7/18/1994	1513	6.56	0.076			
TP	21FLSFWMFDEP01	10/4/1994	1700	0.5	0.084			
TP	21FLSFWMFDEP02	10/4/1994	1715	0.5	0.185			
TP	21FLA 26010952	10/24/1994	933	6.56	0.110	A		
TP	21FLA 26010952	1/30/1995	1330	6.56	0.130			
TP	21FLA 26010952	4/10/1995	925	6.56	0.170			

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TP	21FLA 26010952	8/14/1995	1452	7.87	0.150			
TP	21FLA 26010952	10/16/1995	1305	7.87	0.250			
TP	21FLA 26010952	1/22/1996	1335	7.71	0.170			
TP	21FLGFWFGFCCR0590	2/5/1996	1545	0	0.209			
TP	21FLGFWF03090101-LM-01	2/5/1996	1545	0	0.209		0.01	0.05
TP	21FLA 26010952	4/1/1996	1434	7.54	0.240			
TP	21FLGFWFGFCCR0590	5/6/1996	1505	0	0.222			
TP	21FLGFWF03090101-LM-01	5/6/1996	1505	0	0.222		0.01	0.05
TP	21FLA 26010952	7/8/1996	852	7.54	0.220	A		
TP	21FLA 26010952	7/8/1996	857	7.54	0.230			
TP	21FLGFWF03090101-LM-01	8/5/1996	1615	0	0.173		0.01	0.05
TP	21FLA 26010952	10/28/1996	945	7.22	0.140			
TP	21FLGFWF03090101-LM-01	11/4/1996	1520	0	0.150		0.01	0.05
TP	21FLA 26010952	1/21/1997	950	6.56	0.130			
TP	21FLGFWF03090101-LM-01	2/3/1997	1525	0	0.202		0.01	0.05
TP	21FLA 26010952	4/7/1997	1018	6.72	0.150	A		
TP	21FLA 26010952	4/7/1997	1023	6.89	0.160			
TP	21FLGFWF03090101-LM-01	5/5/1997	0	0	0.157		0.01	0.05
TP	21FLA 26010952	8/4/1997	1345	5.25	0.150			
TP	21FLGFWF03090101-LM-01	8/4/1997	1752	0	0.130		0.01	0.05
TP	21FLA 26010952	10/13/1997	1015	7.54	0.130			
TP	21FLGFWF03090101-LM-01	11/3/1997	1615	0	0.121		0.01	0.05
TP	21FLA 26010952	1/20/1998	1035	7.87	0.170			
TP	21FLA 26010952	4/13/1998	955	7.54	0.160			
TP	21FLGFWF03090101-LM-01	5/4/1998		0	0.173		0.01	0.05
TP	21FLA 26010952	7/6/1998	948	8.2	0.180			
TP	21FLGFWF03090101-LM-01	8/3/1998		0	0.179		0.01	0.05
TP	21FLGFWF03090101-LM-01	11/2/1998	1545	0	0.108		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/1/1999	1130	0	0.130		0.01	0.05
TP	21FLGFWF03090101-LM-01	5/3/1999	1320	0	0.104		0.01	0.05
TP	21FLGFWF03090101-LM-01	8/2/1999	1410	0	0.153		0.01	0.05

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TP	21FLGFWF03090101-LM-01	10/15/1999	1059	0	0.163		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/7/2000	1231	0	0.231		0.01	0.05
TP	21FLGFWF03090101-LM-01	5/15/2000	930	0	0.075		0.01	0.05
TP	21FLGFWF03090101-LM-01	8/14/2000	900	0	0.127		0.01	0.05
TP	21FLGFWF03090101-LM-01	11/13/2000	1000	0	0.274		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/12/2001	830	0	0.346		0.01	0.05
TP	21FLGFWF03090101-LM-01	12/3/2001		0	0.150		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/4/2002	1315	0	0.186		0.01	0.05
TP	21FLGFWF03090101-LM-01	5/6/2002	1015	0.5	0.183		0.01	0.05
TP	21FLGFWF03090101-LM-01	8/5/2002	815	0	0.130		0.01	0.05
TP	21FLGFWF03090101-LM-01	10/28/2002	900	0.5	0.095		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/10/2003	700	0.5	0.179		0.01	0.05
TP	21FLGFWF03090101-LM-01	5/5/2003	1000	0.5	0.068		0.01	0.05
TP	21FLGFWF03090101-LM-01	8/25/2003	920	0.5	0.193		0.01	0.05
TP	21FLGFWF03090101-LM-01	11/3/2003	930	0.5	0.207		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/9/2004	1500	0.5	0.241		0.01	0.05
TP	21FLGFWF03090101-LM-01	5/10/2004	0	0.1	0.117		0.01	0.05
TP	21FLGFWF03090101-LM-01	11/15/2004	1410	0.5	0.163		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/7/2005	0	0.5	0.101		0.01	0.05
TP	21FLGFWF03090101-LM-01	5/2/2005	0	0.5	0.088		0.01	0.05
TP	21FLGFWF03090101-LM-01	8/8/2005	1445	0.1	0.137		0.01	0.05
TP	21FLGFWF03090101-LM-01	12/5/2005	1240	0.1	0.049		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/13/2006	1600	0.5	0.136		0.01	0.05

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Parameter	Station	Date	Time	Depth	Result (mg/L)	rcode	mdl	pql
TP	21FLGFWF03090101-LM-01	5/8/2006	1350	2.5	0.099		0.01	0.05
TP	21FLGFWF03090101-LM-01	8/7/2006	1430	0.1	0.139		0.01	0.05
TP	21FLGFWF03090101-LM-01	11/6/2006	1310	0.1	0.168		0.01	0.05
TP	21FLGFWF03090101-LM-01	2/5/2007	1325	0.1	0.148		0.01	0.05
TP	21FLGFWF03090101-LM-01	5/7/2007	1207	0.1	0.146		0.01	0.05
TP	21FLGFWF03090101-LM-01	8/13/2007	1518	0.1	0.071		0.01	0.05
TP	21FLGFWF03090101-LM-01	11/13/2007	1413	0.1	0.108		0.01	0.05
TP	21FLGW 34147	12/19/2007	1020	0.3	0.110		0.004	0.01
TP	21FLGFWF03090101-LM-01	2/11/2008	1300	0.1	0.131		0.01	0.05
TP	21FLGFWF03090101-LM-01	5/5/2008	1413	0.1	0.107		0.01	0.05
TP	21FLCEN 26011014	2/10/2009	950	0.5	0.096		0.02	0.06
TP	21FLCEN 26011014	2/10/2009	951	0.5	0.099		0.02	0.06
TP	21FLCEN 26011013	2/10/2009	1000	0.5	0.095		0.02	0.06
TP	21FLCEN 26010952	2/10/2009	1010	0.5	0.100		0.02	0.06
TP	21FLCEN 26011183	2/17/2009	1104	0.5	0.110		0.004	0.01
TP	21FLCEN 26011183	2/17/2009	1106	0.5	0.110		0.004	0.01
TP	21FLCEN 26011184	2/17/2009	1114	0.5	0.130		0.004	0.01
TP	21FLCEN 26011185	2/17/2009	1129	0.5	0.160		0.004	0.01
TP	21FLCEN 26010952	5/27/2009	931	0.5	0.150		0.004	0.01
TP	21FLCEN 26011013	5/27/2009	942	0.5	0.140	A	0.004	0.01
TP	21FLCEN 26011014	5/27/2009	956	0.5	0.150		0.004	0.01
TP	21FLCEN 26010952	7/29/2009	928	0.5	0.095		0.004	0.01
TP	21FLCEN 26011013	7/29/2009	938	0.5	0.130	A	0.004	0.01
TP	21FLCEN 26011014	7/29/2009	951	0.5	0.210		0.004	0.01
TP	21FLCEN 26011014	7/29/2009	952	0.5	0.210		0.004	0.01
TP	21FLCEN 26011184	8/24/2009	953	0.5	0.120		0.02	0.05

Corrected Chlorophyll a

Parameter	Station	Date	Time	Depth	Result (ug/L)	rcode	mdl	pql
CCHLA	21FLA 26010952	12/15/1980	1115	1	30.00			
CCHLA	21FLA 26010952	6/9/1981	1300	1	43.70			
CCHLA	21FLA 26010952	1/15/1985	844	1	39.50			
CCHLA	21FLA 26010952	9/24/1985	830	1	44.90			
CCHLA	21FLA 26010952	11/10/1987	815	1.15	50.20			
CCHLA	21FLA 26010952	2/16/1988	835	1.31	16.36			
CCHLA	21FLA 26010952	5/24/1988	905	0.82	49.34			
CCHLA	21FLA 26010952	7/18/1988	815	0.82	52.11			
CCHLA	21FLA 26010952	7/26/1993	825	0.98	84.82			
CCHLA	21FLSFWMFDEP02	9/22/1993	850	0.5	60.90			
CCHLA	21FLSFWMFDEP01	9/22/1993	940	0.5	89.80			
CCHLA	21FLA 26010952	10/11/1993	855	0.66	69.85			
CCHLA	21FLA 26010952	1/24/1994	845	1.15	43.30			
CCHLA	21FLA 26010952	4/11/1994	915	1.15	62.55			
CCHLA	21FLA 26010952	7/18/1994	1513	1.15	44.35			
CCHLA	21FLSFWMFDEP01	10/4/1994	1700	0.5	1.00	U		
CCHLA	21FLSFWMFDEP02	10/4/1994	1715	0.5	32.40			
CCHLA	21FLA 26010952	10/24/1994	933	1.31	40.63			
CCHLA	21FLA 26010952	1/30/1995	1330	1.8	24.86			
CCHLA	21FLA 26010952	4/10/1995	925	1.31	28.33			
CCHLA	21FLA 26010952	8/14/1995	1452	1.31	43.90			
CCHLA	21FLA 26010952	10/16/1995	1305	1.15	43.30			
CCHLA	21FLA 26010952	10/16/1995	1305	1.31	3.49			
CCHLA	21FLA 26010952	1/22/1996	1335	1.31	45.70			
CCHLA	21FLGFWFGFCCR0590	2/5/1996	1545	0	38.50			
CCHLA	21FLGFWF03090101-LM-01	2/5/1996	1545	0	38.50		0.01	0.03
CCHLA	21FLGFWFGFCCR0590	5/6/1996	1505	0	16.00			
CCHLA	21FLGFWF03090101-LM-01	5/6/1996	1505	0	16.00		0.01	0.03
CCHLA	21FLA 26010952	7/8/1996	852	0.82	76.60	A		
CCHLA	21FLGFWF03090101-LM-01	8/5/1996	1615	0	88.10		0.01	0.03
CCHLA	21FLA 26010952	10/28/1996	945	0.98	71.50	A		
CCHLA	21FLGFWF03090101-LM-01	11/4/1996	1520	0	88.90		0.01	0.03
CCHLA	21FLA 26010952	1/21/1997	950	0.82	97.30			
CCHLA	21FLGFWF03090101-LM-01	2/3/1997	1525	0	83.70		0.01	0.03
CCHLA	21FLA 26010952	4/7/1997	1018	3.44	118.70			
CCHLA	21FLA 26010952	4/7/1997	1023	3.44	118.70			
CCHLA	21FLGFWF03090101-LM-01	5/5/1997		0	86.50		0.01	0.03
CCHLA	21FLA 26010952	8/4/1997	1345	0.66	95.22			

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Parameter	Station	Date	Time	Depth	Result	rcode	mdl	pql
					(ug/L)			
CCHLA	21FLGFWF03090101-LM-01	8/4/1997	1752	0	80.90		0.01	0.03
CCHLA	21FLA 26010952	10/13/1997	1015	0.82	77.39			
CCHLA	21FLGFWF03090101-LM-01	11/3/1997	1615	0	56.10		0.01	0.03
CCHLA	21FLA 26010952	1/20/1998	1035	0.98	38.42			
CCHLA	21FLA 26010952	4/13/1998	955	0.82	67.50			
CCHLA	21FLGFWF03090101-LM-01	5/4/1998		0	47.70		0.01	0.03
CCHLA	21FLA 26010952	7/6/1998	948	0.98	77.00			
CCHLA	21FLGFWF03090101-LM-01	8/3/1998		0	66.50		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	11/2/1998	1545	0	56.10		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/1/1999	1130	0	80.10		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	5/3/1999	1320	0	124.20		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	8/2/1999	1410	0	64.10		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	10/15/1999	1059	0	59.30		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/7/2000	1231	0	61.70		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	5/15/2000	930	0	27.20		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	8/14/2000	900	0	75.30		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	11/13/2000	1000	0	89.70		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/12/2001	830	0	92.90		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	12/3/2001		0	50.50		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/4/2002	1315	0	58.50		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	5/6/2002	1015	0.5	55.50		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	8/5/2002	815	0	32.40		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	10/28/2002	900	0.5	31.67		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/10/2003	700	0.5	19.54		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	5/5/2003	1000	0.5	18.60		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	8/25/2003	920	0.5	47.10		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	11/3/2003	930	0.5	1.00	&	0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/9/2004	1500	0.5	84.70		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	5/10/2004	0	0.1	40.50		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	11/15/2004	1410	0.5	53.90		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/7/2005	0	0.5	37.50		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	5/2/2005	0	0.5	58.40		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	8/8/2005	1445	0.1	63.60		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	12/5/2005	1240	0.1	51.80		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/13/2006	1600	0.5	49.30		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	5/8/2006	1350	2.5	44.10		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	8/7/2006	1430	0.1	102.10		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	11/6/2006	1310	0.1	115.60		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	2/5/2007	1325	0.1	60.80		0.01	0.03
CCHLA	21FLGFWF03090101-LM-01	5/7/2007	1207	0.1	79.70		0.01	0.03

DRAFT Nutrient TMDL Report for Lake Marian

Parameter	Station	Date	Time	Depth	Result	rcode	mdl	pql
					(ug/L)			
CCHLA	21FLGFWF03090101-LM-01	8/13/2007	1518	0.1	47.10		1	5
CCHLA	21FLGFWF03090101-LM-01	11/13/2007	1413	0.1	50.20		1	5
CCHLA	21FLGW 34147	12/19/2007	1020	0.3	66.00		2.8	8.5
CCHLA	21FLGFWF03090101-LM-01	2/11/2008	1300	0.1	72.70		1	5
CCHLA	21FLGFWF03090101-LM-01	5/5/2008	1413	0.1	62.00		1	5
CCHLA	21FLCEN 26011014	2/10/2009	950	0.5	37.00		1.1	3.5
CCHLA	21FLCEN 26011014	2/10/2009	951	0.5	39.00		0.92	2.8
CCHLA	21FLCEN 26011013	2/10/2009	1000	0.5	39.00		0.85	2.6
CCHLA	21FLCEN 26010952	2/10/2009	1010	0.5	46.00		1	3.2
CCHLA	21FLCEN 26011183	2/17/2009	1104	0.5	58.00		0.92	2.8
CCHLA	21FLCEN 26011183	2/17/2009	1106	0.5	56.00		1.6	4.9
CCHLA	21FLCEN 26011184	2/17/2009	1114	0.5	71.00		1.2	3.7
CCHLA	21FLCEN 26011185	2/17/2009	1129	0.5	81.00		1.3	4.1
CCHLA	21FLCEN 26010952	5/27/2009	931	0.5	110.00		2.8	8.5
CCHLA	21FLCEN 26011013	5/27/2009	942	0.5	140.00		2.8	8.5
CCHLA	21FLCEN 26011014	5/27/2009	956	0.5	130.00		2.8	8.5
CCHLA	21FLCEN 26010952	7/29/2009	928	0.5	61.00		1.4	4.2
CCHLA	21FLCEN 26011013	7/29/2009	938	0.5	55.00		1.8	5.7
CCHLA	21FLCEN 26011014	7/29/2009	951	0.5	74.00		1.4	4.2
CCHLA	21FLCEN 26011014	7/29/2009	952	0.5	60.00		1.1	3.4
CCHLA	21FLCEN 26011184	8/24/2009	953	0.5	81.00		2	6.1